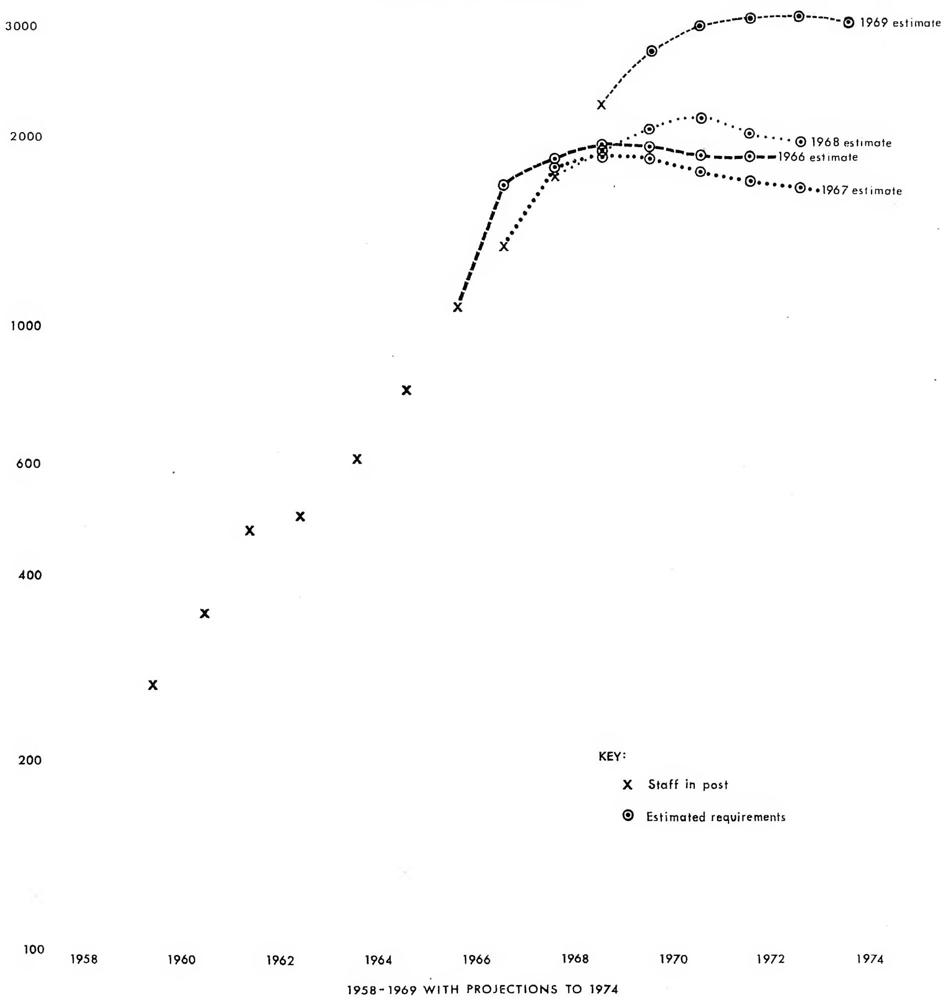
Table 6.1

Staff engaged on ADP duties



1 The figures relate to E.O's and above (including equivalent military grades)

2 G.P.O staff are excluded

1 Introduction

1 The review team was formed in March 1969 following an indication from the Government Statistical Services Advisory Committee on Computers of the need for a major review by a full time team of the Government's computer plans for the next decade.

2 The team's terms of reference were:

(a) to review plans for the use of computers by Government departments and, taking account of developments in computer technology, to forecast the possible overall ADP requirements of Government in ten years' time;

(b) to consider the possible effects on staff of the satisfaction of these requirements;

(c) to indicate the scope for the integration of particular requirements in one comprehensive plan;

(d) to determine the extent to which this comprehensive plan might be constrained by projects already at an advanced stage, and by financial, manpower, organisational and policy considerations;

and to report with recommendations by September 1969.

3 The membership of the review team was:

W R Atkinson, Assistant Secretary,
Civil Service Department
P Hearson, Chief Executive Officer,
Civil Service Department
R Ingham, Senior Consultant,
Urwick Dynamics Limited

4 We recognise that this report will be read by laymen as well as by people with wide knowledge and experience of computers. As far as possible we err on the side of the lay reader and try to avoid using technical terms. Where the use of these terms is unavoidable, and their meaning is not self-evident, we include them in a glossary with this report. Where we refer to departments, or to particular grades of staff, we use the full title on the first occasion followed by the appropriate initials: thereafter we rely mainly on initials.

5 The terms 'computing' and 'automatic data processing' are frequently regarded as synonymous. In this report we use the term 'automatic data processing' or 'ADP' when we are referring exclusively to administrative and general purpose data processing (which is analagous to commercial data processing outside Government). We use the term 'computing' to cover both the use of computers for scientific and technical purposes and their use generally in Government.

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6 The terms of reference direct us to review plans for the use of computers by Government departments. Our study is not therefore confined exclusively to those computers which are used for administrative and general purpose data processing, though we disregard those which are used on-line for specific research or development activities and in process control, weapons systems,[1] avionics and simulators. We have not taken computing in the Post Office into account. It is right, in our view, that computers used for scientific purposes should not be excluded entirely from the review. Some computer installations are now used for both general administrative data processing and for scientific computing. Furthermore, scientific computing requirements have to be taken into account in framing the Government's policy for purchasing computers and they increase the overall demand for specialist personnel to operate the computers.

7 We concentrate on administrative and general purpose data processing. We do so partly because, in the time and with the resources available, we could not study the purpose lying behind the use of scientific computers and partly because administrative applications have greater effect upon the general work of departments than do scientific applications.

8 In Chapter Two of the report we describe the present stage of and acknowledged weaknesses in the use of computers in Government. In Chapter Three we indicate the new applications for which computers may be used in Government during the next decade, and the equipment including software which will probably become available for these purposes; and in Chapter Four we examine, specifically, the extent to which these developments appear likely to include the integration of computer systems and associated procedures. Our method is first to consider those developments which can be predicted with confidence on the basis of declared policies, well-defined trends and known technological improvements and, secondly, to outline some of the less tangible longer term possibilities which could conceivably come about. We advance the latter suggestions with diffidence, in the sure knowledge that events will belie at least some of our forecasts. Much will depend on unpredictable changes in the organisation and policy of Government, and in technology.

9 On the basis of these projections we then make a heavily qualified estimate in Chapter Five of the power and type of the computers and other equipment which will be required to meet the demands on Government in ten years' time, including those of the scientist. In Chapter Six we estimate the number of staff specialised in ADP techniques who must be found and trained if progress on the scale we believe possible is to be achieved, and we assess the implications of this progress for Civil Servants generally. In Chapter Seven we indicate how this effort is directed and organised both centrally and within particular Departments. Our main findings and recommendations are summarised in Chapter Eight.

10 It has not been possible in six months to examine in depth all matters within our terms of reference. Our prime object is, therefore, to identify problems requiring further examination and to draw attention to any action needed immediately in order to safeguard the position for the future. We hope in this way to provide an informed basis for shorter term planning, and to lay

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[1] 'System' has two meanings in the report – see glossary.

a foundation for the longer term developments to meet the emerging needs of the 1970s.

11 We acknowledge the unstinted assistance we have received from all those we consulted in the course of our review. Departments are extremely hard-pressed, and our visits to them never occupied less than half a day and frequently lasted longer. But senior members of the staff, including those in ADP units and establishments divisions, placed themselves entirely at our disposal and gave us their full cooperation. The same holds true for all the other organisations and individuals we approached, including the various divisions in the Civil Service Department (CSD).

12 We should place on record our particular debt to the Central Statistical Office (CSO); and, among the computer operating departments, to the Ministry of Defence (MOD), the Department of Health and Social Security (DHSS) and Inland Revenue (IR). We selected these departments for particular attention and spent the equivalent of several full days with each of them, both at head office and at installations. We consulted the staff of Ministry of Technology (Mintech) frequently and at length on many matters concerning our review and obtained invaluable assistance. Finally, we could not have completed our task without the wholehearted support and encouragement of all members of Management Services (Computers) Division (MS(C) Division) in CSD who, throughout our review, responded promptly to our many requests for information on a wide range of subjects covering all aspects of ADP in Government.

13 We have made every endeavour to ensure that the report is factually correct throughout. In such a swiftly changing and rapidly expanding subject this is difficult to achieve, and we apologise for any inadvertent mistakes. The comments, proposals and recommendations in the report are, of course, solely those of the review team. They must not be taken to reflect the opinions and policies of CSD and other departments.

2 The use of computers in government departments

14 In this part of the report we draw upon the extensive information obtained from MS(C) Division and operating departments to give a general picture of the use of computers in central Government at the present time, including the great variety of equipment to be found in departments and the wide range of applications which are undertaken. We then make an appraisal of past and present applications and of equipment. This is not an historical account of the growth of computer applications in Government over the past ten years or so. Nor is it an inquest. It is intended primarily to provide a suitable background against which to consider further developments and new applications. We hope also, through summarising the lessons learned by departments as they have acquired first-hand experience of computers, to indicate the basis for some of the recommendations made later in the report, and to provide some general guide lines for the future.

15 We deal in Chapter Six and Seven respectively with personnel problems and the present organisation of computing in Government. In this way we relate present arrangements directly to future requirements in these two crucial areas.

Work done at present

16 At 30 June 1969 there were 182 computers in use and 34 on order in Government departments. These included 95 computers in use and 20 on order for administrative and general purpose data processing, and 87 in use and 14 on order for scientific and technical purposes.

Scale of computing

17 We give in Table 2.1 the number of computers, and computer series, in use in departments at 30 June 1969. The table also includes the cumulative expenditure actually incurred by individual departments on computers up to that date, and the number of systems designers and programmers in post in each department at 31 March 1969. Taken together we believe that the figures give a better, though still broad, indication of the scale of computing in each department than can be obtained from a simple statement of numbers. Numbers of computers alone can be misleading because computer systems vary in size and in power.

18 On this basis three departments stand out as the major users of computers in Government at the present time – ie MOD as a very large user, both

for administrative and for scientific purposes,[1] DHSS as a very large administrative user, and Mintech as a very large scientific user with special computer responsibilities. The very large number of computers in MOD and Mintech is attributable to many small computers used for scientific and technical purposes.

19 Thirteen of the other departments, with between 36 and 105 specialist computing staff to handle their applications (a mean of 71) would, on commercial standards, each be classified as substantial users and expected to be virtually self-sufficient in ADP terms. The remaining four – Export Credit Guarantee Department (ECGD); Housing and Local Government (MHLG); Ordnance Survey; Overseas Development (ODM) – are at present small users. In the commercial world, concerns with small applications of this kind would expect external support of the kind provided by MS(C) Division if, indeed, they did not decide that a computer bureau would best meet their ADP requirements.

Table 2.1

Number and no. of series of computers used by departments: cumulative investment in computers and specialist staff requirements

A	B	C	D	E
Department	Number of Computers	Number of Computer Series	Cumulative Investment (£'000)	Specialist[2] Staff
1 Agriculture, Fisheries and Food ..	5	3	1,297	55
2 Customs and Excise	1	1	317	56
3 MOD (Navy)	40	15	4,441	216
(Army)	25	9	3,776	216
(Air)	15	8	3,609	232
(Central)	1	1	321	85
4 Education and Science	2	2	489	61
5 Employment and Productivity ..	1	1	182	85
6 Export Credit Guarantee	1	1	69	4
7 General Register Office	1	1	192	36
8 Health and Social Security	9	5	4,064	295
9 Home Office/Met. Police	4	3	625	102
10 Housing and Local Government ..	3	2	101	12
11 Inland Revenue	5	3	869	69
12 National Savings	1	1	582	76
13 Ordnance Survey	1	1	94	9
14 Overseas Development	2	1	58	3
15 Public Building and Works	5	2	1,052	105
16 Stationery Office	5	3	1,438	82
17 Technology	45	15	6,017	119
18 Trade	4	3	1,114	39
19 Transport	2	2	15	92
20 Scottish Office	4	3	588	66
8 Departments without installations	—	—	—	68
	182		31,310	2,183

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[1] Administrative and scientific computing in MOD accounts for approximately one-third of the Government's computer power.

[2] See paras. 294 and 295 for a definition of specialist staff. The staff totals exclude those scientific officers who undertake their own programming. To this extent the figures understate somewhat the commitment of those departments, notably MOD and Mintech, which use computers extensively for scientific purposes. The allocation of computers between MOD (Central) and the three service departments does not fully reflect the effect of centralisation. Some computers now centrally managed are still recorded with the previous service departments.

Variety of computers

20 Column C in Table 2.1 shows the number of computer series used by each department and therefore gives some indication of the spread of different machines in central Government at the present time. The full extent of this spread can be gauged from Table 2.2.

Table 2.2

No. of computers by series installed in or on order for Government departments at 30 June 1969

A Series	B Installed	C On Order	D Total
ICL 1900	33	14	47
ICL System 4	3	2	5
ICL 4100	10	1	11
ICL Atlas	1	—	1
ICL KDF 9	3	—	3
ICL Leo*	9	2	11
ICL 1100/1200/1300	14	—	14
ICL Deuce	4	—	4
ICL 500/800*	16	1	17
ICL 2400	3	—	3
DEC-PDP	7	—	7
Ferranti – older models	10	—	10
Ferranti – Argus and 1600	7	3	10
GEC – Elliott – all types	15	4	19
Honeywell – all types	4	2	6
IBM 360	2	2	4
IBM 705	2	—	2
IBM 1130	6	1	7
IBM 1400	9	—	9
IBM 1620	1	—	1
Univac 490	2	—	2
Univac 1100	2	—	2
AEI 1010	3	—	3
GEIS Gamma 10	3	—	3
Monrobot XI	2	—	2
NCR 315	1	—	1
NCR 500	7	—	7
Philips Data 8000	—	2	2
SDS all types	2	—	2
Purpose-built	1	—	1
	182	34	216

* The two Leo machines on order are the result of the large order placed by the Post Office for the Leo series and are for DNS. The ICL 500/800 is being purchased second hand for training purposes.

21 On this classification, in which machines with very limited compatibility are included as a single series, there are 30 different series of computers in use or on order for Government. The individual models within each series are too numerous to mention. This spread severely limits the extent of compatibility between different computer installations. We discuss the implications of this in paragraphs 50 to 53 (and see also Appendix 1 for a definition and explana-

tion of compatibility). In this connection it is important to note that while the ICL 1900 series represents only some 18 per cent of the machines at present installed in departments, it represents over 40 per cent of the computers now on order; and 60 per cent on the administrative side alone. The specialised computing requirements of scientific establishments give rise to greater variety than on the administrative side. No series is dominant.

Range of applications

22 As Table 2.3 shows, on a broad classification which does not take separate account of a number of special applications, computers already installed in Departments are used for some 15 different kinds of application.

Table 2.3

*Range of computer applications in central Government**

A Classification	B No. of Depts.	C No. of Comp. Series†
1 Revenue Assessment and Collection	2	3
2 Collection of Social Security Contributions	1	1
3 Other Cash Collections from the Public (ie Home Office Traffic Tickets)	1	1
4 Banking and Savings (Department of National Savings, DNS)	1	1
5 Disbursement:		
(a) Social Security and Pensions (DHSS; Paymaster General's Office, PGO)	2	3
(b) Business (ie subsidies)	2	3
(c) Local Authority	1	1
6 Departmental Accounting (including Bill-paying)	7	5
7 Pay (and Personnel)	18	8
8 Stores	5	8
9 Production Control	2	3
10 Maintenance and Repair (Technical Performance)	1	1
11 Statistics:		
(a) Population and Personal	4	5
(b) Business	6	5
(c) Government Finance	2	1
12 Bureaux	3	2
13 Special‡	4	3
14 Scientific and Technical	12	15
15 Training	4	5

* This table is confined to computers installed at 30 June 1969.

† The computer series in Column C is given across all departments within each classification. Where two or more departments use the same series for the same application only one is added to the total. The figures in Column C are therefore an indication of compatibility within each classification – ie the higher the figure in Column C in comparison with the corresponding figure in Column B the lower the level of compatibility.

‡ These cover export insurance in ECGD; survey work in Ordnance Survey; information retrieval in Mintech and road transport problems in Ministry of Transport (MOT).

23 The broad basis of classification by major function adopted for Table 2.3 will be self-evident, as will be the departments which are concerned with particular functions. For example, revenue assessment and collection involves Customs and Excise and IR; and social security collections and disbursements

DHSS. Stores applications are confined to MOD, Ministry of Public Building and Works (MPBW) and HM Stationery Office (HMSO). A large number of departments have payroll applications, but very few have so far extended this to cover personnel records. A significant number also uses computers for statistical purposes.

24 More general applications, such as accounts, pay and statistics, are most often carried out on computers which are also used for other tasks and may not necessarily belong to the department providing the work. But the bulk of computing work, and certainly almost all which is associated with the major functions of a department or branch, is assigned to dedicated and, often, large systems. This is true of scientific computing as well as of administrative data processing: most scientific establishments with computers use them exclusively for their own purposes. In ADP it characterises such large systems as those for revenue and social security work, national savings, defence supplies and Service pay.

25 There are several explanations for this marked degree of dedication. One is that, in the early stages of computing in Government, departments had to develop their own applications independently in order to get them off the ground reasonably quickly and to gain working experience with computers. But there are other, more fundamental reasons, which seem likely to perpetuate the present pattern for the future. Departments wish to retain full control of activities for which they bear ultimate responsibility. The time-critical nature of much of their work may demand that they have priority use of the computer even where the volume of work and the special design of the system might not of themselves justify a separate installation.

Geographical distribution

26 Table 2.4 shows the distribution of the computers at present in use in departments over the ten economic planning regions in England, Scotland and Wales.

Table 2.4

A Economic Planning Region	B No. of Depts.	C No. of Computer Series	D Investment in Hardware* (£'000)
1 { London	9	10	1,772
1 { South East	16	22	13,799
2 South West	3	12	2,978
3 Wales	3	3	169
4 East Anglia	2	3	2,611
5 East Midlands	2	3	661
6 West Midlands	2	5	879
7 North West	6	6	1,608
8 Yorks and Humberside	2	2	119
9 Northern	4	5	3,785
10 Scotland	6	12	2,784
Total			31,165

* The investment figures are as in Table 2.1, installed at 30 June 1969.

27 This table does not have any great historical significance. It presumably reflects the disposition of the user Departments and their natural wish, for which there has been some operational justification, to have their computers as close as possible to the source of the work for which they have been provided. Dispersal policy, to which we refer later in this Chapter, has not apparently yet had time in which to make a noticeable impact on the geographical distribution of departmental computers.

28 The present location of computer installations will be a vital factor to be taken into account, along with the existing and proposed pattern of computer networks, and dispersal considerations, in planning future bureau and network developments within Government.

Replacement of existing computers

29 The future volume of computing in Government will depend in part upon the extent to which existing computer systems expand or are replaced, as well as upon the development of new applications upon which we concentrate in Parts Three and Four. Up to the present time only a small number of the very early computers has been retired, but replacement is now proceeding on a wide scale as the original machines come to the end of their effective lives or are otherwise unable economically to carry out the tasks for which they were provided. This applies particularly within MOD which was among the earliest users of computers in Government.

30 Very rarely at the present time is there a straightforward replacement of a computer. At very least future growth of the existing workload has to be provided for. More often than not opportunity is also taken to refine or develop the original system to undertake further tasks. For example, the Army Department is expanding its system for soldiers' pay so that, on replacement of the computers at Worthy Down, it will be able to process some personnel records; and, in the field of stores, MOD generally is seeking continually to expand its range of computer applications. The same trend is found in scientific computing. Developments of this kind may not add numerically to the list of applications in Table 2.3, which may therefore be taken as the base for future forecasting to which entirely new applications can be added. In qualitative terms, however, the changes may be such as to transform the original systems almost out of recognition and, at risk of some duplication, we make special reference to developments of this kind in Chapters Three and Four.

Appraisal of applications and equipment

31 Our appraisal is confined to applications and equipment. It is made from such information as was available to us within CSD, supplemented by many discussions with departments and some visits to installations. It is limited in extent partly because we did not consider it to be a proper use of our time to undertake what we could not hope to make—a comprehensive review of past and present performance. But, significantly, it is also limited by the almost complete absence within Government of any machinery for the systematic post-implementation appraisal, under such heads as applications, organisation

and methods, of the range of activities which makes up a computer project. This defect is attributable to shortage of staff to carry out the work.

32 There are arrangements for the annual review of the profitability of computer projects and this is a useful monitoring device. It draws attention to the extent to which expectations of expenditure and savings are being achieved in reality, though it suffers from the disadvantage of concentrating on factors which can be expressed in financial terms. But these reviews do not so far appear to have been undertaken consistently and conscientiously by many of the departments using computers, and in our view are not in any case an adequate substitute for centrally directed post-implementation studies of major installations. We regard the absence of such arrangements, including objective and generally accepted standards of appraisal, as a weakness in Government data processing: it is certainly a deficiency for which we have not been able to compensate by our review.

Automatic data processing applications

33 In this area the first tasks to have been put on the computer were comparatively straightforward ones, either of a general kind such as payroll, stock recording, departmental statistics, or of a specific departmental nature like the recording of graduated contributions. More advanced applications giving rise to complex problems of systems design have followed as departments have acquired experience in ADP. Many of these later developments are still at an early stage. We include in this category such tasks as the payment of short-term social security benefits (DHSS); the centralisation of PAYE records (IR); comprehensive pay and personnel systems (eg MOD (Air)) and the limited integration of separate departmental systems (eg MPBW).

34 Most schemes have germinated within the departments directly concerned. The impetus has frequently been the wish to achieve staff savings and improve efficiency, or the imperative need to overcome mounting staff shortages by mechanical means. On occasion political and policy decisions have prompted the use of computers, for example where they originate a particular operation which could not be carried out or carried out quickly enough in any other way.

35 We do not consider that the choice of ADP applications or the order in which they have been tackled can be seriously criticised. The general course of events certainly conforms to the pattern of development outside Government. But there has been no central plan for Government as a whole, and the strong departmental influence is reflected in the selection of equipment as well as in the choice of application.

36 Our only challenge would be on the recent pace of automation in Government. We accept that there is some validity in the criticism that departments have slipped from their earlier position as national leaders in computer developments. There is further cause for concern in the time taken first to approve projects and then to implement them. These failings are in our view primarily attributable to deficiencies in organisation and shortages of skilled manpower with which we deal subsequently in the report. It is, however, little comfort to know that in the past the consequences of delay within departments have frequently been masked by external delays in supplying the computer or in providing the accommodation to house it.

37 We should also record the opinion of Mintech that while, on the whole, departments make a success of adapting a computer system to undertake existing functions they pay insufficient attention to the possibilities of re-designing these functions in order to get the greatest advantage from the latest developments in computers. To the extent that this criticism is valid it again reflects problems in personnel and organisation.

Scientific computing applications

38 We have not ourselves reviewed this specialised topic. It is our impression, however, that scientific computing in Government is if anything more fragmented than ADP because of the tendency in the past to acquire a large number of smaller computers for particular tasks in separate establishments, in addition to a few larger machines for general use.

Documentation and working methods

39 The impression we gained from our visits was that, at most installations, efforts have been made with varying degrees of success to standardize within the installation on documentation and working methods for systems design and computer programming. It is, however, a corollary to the wide variety of equipment in Government to which we have already referred that there are many different standards of this kind, and this must lead to duplication of effort. It is recognised by some of the large users of computers in Government, notably MOD, that a formidable amount of work will be involved in establishing common standards, applying them generally and building up fully referenced libraries of systems and programs.

Pay off

40 We have been unable to obtain comprehensive and wholly reliable information from which to assess the actual profitability of ADP schemes now in operation. We have already commented upon the limited value of the annual review based upon departmental costing returns. The position is further bedevilled by the change in the basis of costing from 1966 onwards (ie from amortisation and interest to discounted cash flow); still more by changes, which were not anticipated at the planning stage, in the nature and volume of work undertaken by the computers after they have come into use. This makes it extremely difficult if not impossible to compare like with like in order to get at a meaningful estimate of the financial benefit.

41 One of the prime justifications for many of the present ADP systems in Government was staff saving, to which the greater part of their estimated profitability was attributed. This item has added significance in a period when salaries and staff costs are steadily rising. As the experience of MOD with its Chilwell and Donnington stores systems showed, this factor can turn a project which initially shows a loss into one with a substantial positive value.

42 Departments have claimed that about 2,500 staff were in fact saved up to March 1968, with a further 1,000 expected in 1968/69. They estimate that in all some 13,000 staff will be saved from systems now either in operation or at an advanced state of planning. These figures must be treated with great

reserve, and we would doubt whether in the event they will be fully realised. The unexpected changes and developments in systems which complicate the assessment of profitability will also upset staffing projections. In many cases it will not be possible realistically to compare staff figures for the previous system with those of the ADP system. But the figures do serve as an indication of the scale of ADP in Government and the benefits to be derived from its intelligent application.

General experience

43 Nearly all the computer-using departments have acknowledged with hindsight that, with their early ADP projects, they had made some common mistakes. Generally there had been inadequate planning at a high enough level in the early stages, which underlined the importance of bringing in key personnel at the outset and developing the unit downwards through project and section leaders to the junior designers and programmers. With some applications departments had been over-cautious: for example, by continuing for too long the period of parallel running of the original manual and the ADP systems. More frequently, however, they had been too optimistic and over-ambitious. They had underestimated, in some cases seriously, the systems and programming effort needed to implement a project, and very often the computer capacity required to undertake the intended task. Costing had been inadequate and forecast savings had not been realised. There had been a tendency, difficult to resist in the first flush of enthusiasm, to try to build too many refinements and subtleties into the system. This over-extended their limited and often inexperienced resources, and caused delay.

44 This frank catalogue is not unique to Government. It mirrors general experience at a pioneering stage in new techniques when those developing the systems could not turn to experienced advisers for guidance. Moreover, in contrast to some commercial experiences, there do not appear to have been any total failures. Most of the lessons appear now to have been learned, certainly in those departments with the longest ADP experience. Expectation is coming closer to reality. But there are certainly no grounds for complacency. We are apprehensive that departments coming late to ADP will be permitted to make the same mistakes as the pioneers; and that some of the more ambitious schemes now being developed could be impaired by the same consequencies of over-optimism and underestimation as affected earlier applications.

Centralisation and dispersal

45 In some departments the transfer of work processes to computers has been combined with the centralisation of that work either in one place (as with the Ministry of Transport vehicle licensing scheme) or in a small number of large regional offices (as with the IR PAYE scheme), so that the work can be processed more efficiently. This is centralisation. In some departments[3] the location of computer installations, and in some cases the offices for the associated work procedures, has been determined with careful regard to the

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[3] eg Business Statistics Office to Newport; Department of Education and Science (DES) to Darlington; DEP to Runcorn; General Register Office (GRO) to Tichfield; IR to various places; DNS to Glasgow; MPBW to Hastings; HMSO to Norwich.

policy of dispersing work from the London area, and to regional development policy generally. This is termed dispersal. With some departments centralisation has been combined with dispersal.

46. There can be no doubt that centralisation, however necessary or desirable in the longer term, complicates considerably the job of setting up a computer-based system. It gives rise to major organisational problems which impinge directly or indirectly upon the implementation of the computer system. It may involve the movement of large numbers of staff from one part of the country to another. Careful synchronisation of a number of critical matters including accommodation is essential, but difficult to achieve in practice.

47 Intrinsically, dispersal appears to cause relatively few problems and, particularly where it involves movement of work out of London, can bring considerable advantages. The main criticism made by a number of departments is that unless locations are fixed quickly, and at an early stage in project planning, dispersal makes for delay (for example location can affect the basic design of the system) and may give rise to difficulties with the Staff Side. There have been other problems over the transfer of key personnel including ADP specialists to the dispersed location, unless this is in an attractive area, and over the provision of accommodation at the right time. Planning generally becomes more complicated. At the operational stage some departments have found snags when the computer installation has been dispersed and the associated procedures have not. On the other hand, departments which have moved their computer units out of London have, in the main, relieved some of their staffing problems. They have been able to recruit locally good quality staff in the numbers they require – eg for data preparation – and wastage rates have been cut.

Suitability of equipment

48 Computers acquired by departments over the course of a decade during which technology has advanced rapidly now extend over a wide range of degrees of suitability. Some which were the most up-to-date equipment at the time they were acquired are now barely adequate, simply because the earlier computers were limited in capacity and performance. Others are still eminently fitted to the tasks they are required to undertake. On the whole we consider that the equipment acquired for individual purposes has probably been better suited to those purposes than has been the case outside Government.

49 There have, of course, been some major mistakes, particularly in underestimating the size and performance of the computer or computers needed to carry out particular tasks. These failings are partly attributable to inexperience in ADP units. In the almost unanimous opinion of departments they stem also from poor technical support from, and over-enthusiastic salesmanship by, the computer manufacturers. While some users acknowledge good maintenance facilities and, at least in the recent past, adequate software support, a majority of departments complain that the manufacturers have underestimated difficulties and made extravagant and sometimes misleading claims for both hardware and software. They have also caused difficulties by the late delivery of computers.

Compatibility

50 We indicated in paragraph 21 that there are at present 30 different series

or ranges of computers in use or on order for Government. This remarkable spread is accounted for by the fact that, until recently, most decisions to purchase computers for departments were taken with regard only to the suitability of a particular machine for a well-defined task at the time of ordering. Only a minority of departments, or even branches within departments, have so far concentrated on a particular series of computer for all their data processing,[4] even for similar applications. The resultant incompatibility is perhaps the most serious deficiency in the computer equipment in use in Government today.

51 There are several kinds of compatibility (see Appendix 1, paragraphs 8–13). The basic form concerns the interchange of data between one computer system and another. This is in fact now possible between most machines in Government, though only at a cost in terms of additional hardware or software, time and efficiency where installations use different series. Programs may also be exchangeable between different series, though again only at the cost of extensive program rewriting or other techniques. But, as a general rule, the interchange of data, exchange of programs and the capacity to transfer work freely is possible without additional cost and inconvenience only where different users use the same model or, in part, where one operates a larger model in the same series.

52 We consider in Chapter Four the critical importance of compatibility and the associated subject of standards[5] for the integration of departmental systems. The lack of them will certainly restrict the pace and scope of future developments. We cannot quantify the cost of incompatibility up to the present time, but it must be considerable. We know that it reduces the flexibility of ADP equipment and has led to extensive duplication, for example in the separate development by departments of payroll systems. Specialist staff are less interchangeable between systems and this too reflects in higher manpower and training costs. Departments can seldom look to other branches or departments to provide adequate standby facilities in the event of breakdown, and insure as best they can by refining or expanding their systems in a way which, probably, they would not consider to be necessary if there was more general compatibility.

53 The position is improving somewhat in these respects with the increasing reliance of Government departments on ICL equipment in the 1900 series. But, to a smaller extent, departments are also acquiring machines in the ICL System 4 series. This diversification of the leading British manufacturer into two series will unfortunately perpetuate some of the more serious consequences of incompatibility in that each series has a fundamentally different architecture. This is a continuing and so far apparently unresolved problem.

Utilisation of equipment

54 (a) The original justification for most of the earlier Automatic Data Processing installations was based on single shift working. An agreement

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[4] eg MOD (IBM 1400 for naval stores in Dockyards: ICL 1900 for RAF equipment supply depots); IR (ICL 1900 for PAYE and further applications); DNS (Leo III and 326; MPBW (ICL 1300).

[5] A definition and explanation of standards is given in Appendix 1, paragraphs 1–7.

was reached with the National Staff Side in 1968 for 120 hours operational use of ADP systems per week, and most departments are now working up to between 75 and 100 hours per week. Some are already operating for 100–120 hours. A few departments are still working on single shifts and MS(C) Division is pressing them to consider as a matter of urgency how best they can utilise their spare capacity: however, the total capacity involved is fairly small.

(b) One or two operating departments suggested to us that work which was not really suitable for data processing was sometimes put on the computer simply to fill up time. We found no evidence to indicate that this was anything more than a rare occurrence. Moreover, MS(C) Division has maintained a central check on the relatively small amount of spare capacity which has been available on ADP installations so that this can be used to maximum advantage. In the main it is used for non-repetitive short-term jobs. The scope for spreading work in this fashion to relieve bottlenecks and take up spare capacity is restricted, of course, by the present lack of compatibility. If, because of this, a job has to be reprogrammed for another series, and the staff for this conversion task are not available, delay ensues.[6]

(c) On the whole Government ADP systems are probably not being used as fully as the most efficient commercial installations. Nevertheless, with the exception of a few departments, it is our view that the level of utilisation is now satisfactory, taking due account of the limiting effects of incompatibility.

Operating

55 The general impression we gained from our visits to installations was that a high standard is exercised over the operating of equipment and the flow of documents. In some, elaborate statistics are maintained about equipment performance and on the source of errors.

Constraints

56 We look at possible constraints upon the planned development of computers almost wholly in the context of the future. In quantifying the future computer requirements of departments we give a very approximate indication at current prices of the possible scale of the investment that will be required in computer hardware. Financial, manpower, organisational and policy considerations are reviewed in the Chapters on integration, personnel and organisation.

57 In reviewing the past we obtained no evidence to suggest that the introduction of ADP into departments has so far been seriously restricted by any of the constraints referred to in our terms of reference. The provision of finance has depended in most cases upon the straightforward evaluation of estimated

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[6] A classic example of this occurred when DEP could not accommodate entirely the Family Expenditure Survey on its own ICL 1100. There was no compatible system in Government available to carry out this work. In the event it had to be reprogrammed for ICL 1900's.

cash savings, in recent years on the discounted cash flow basis. Provided the prescribed criteria have been satisfied, projects have been authorised: a situation in which projects satisfying the tests have had to be put in a queue for money in some order of national priority does not seem to have arisen.[7] Manpower shortages have, however, caused some delay in either starting some worthwhile projects or completing them. It was put to us by some departmental ADP units that the apathetic attitude of senior staff towards computers had also retarded the exploitation of ADP on the scale which should have been possible.

58 The lack of effective coordinating machinery and central planning has not been a cause of serious concern in the past when departments were concentrating, properly enough in these early stages, on internal applications. The consequences of this are for the future. We indicate in Chapter Four how limited compatibility, and the separate commitment of particular departments to major projects until well through the 1970s, which may be attributed at least in part to uncoordinated development, could retard future progress.

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[7] The position is different with scientific computing. The expenditure normally falls on the departmental Vote and a choice has sometimes to be made between a computer and another piece of equipment.

3 Forecast of future computer applications

59 We are required by our terms of reference to take into account developments in computer technology when reviewing plans and forecasting the possible overall requirements of Government for computers in ten years' time. In this part of the report we begin by examining likely developments in both hardware and software and then follow by indicating the computer applications which are forecast during the 1970s.

Forecast of technological developments

60 We must stress the hazards of long term technological forecasting in an industry characterised by rapid growth and technical innovation. New discoveries cannot be anticipated nor the commercial viability of research projects accurately predicted. Partly for these reasons, and also on grounds of commercial security, computer manufacturers are understandably reluctant to discuss developments. We have therefore relied in the main on other sources of information which we have mentioned in Appendix 2. This appendix contains a detailed account of the information we have assembled.

61 The essential features of a computer and its peripheral equipment are:
- its speed of computation and of input/output;
- the size and accessibility of its storage;
- the ease with which it can be programmed.

These essential features are interdependent, and there have been improvements in all of them since the first computer was built. The improvements have sometimes been dramatic: at other times they have been gradual.

62 We would expect that improvements will continue to be made in all these essential features. These will contribute to better performance on existing applications, and Government will adopt them as they occur in so far as it is practicable and economic to do so. The speed with which improvements will be adopted will depend very much on the extent to which departments are committed to particular series for existing applications. Many small improvements will not individually be very noticeable. In this summary we cover some of the smaller improvements which are forecast but we concentrate on the bigger ones.

63 We refer below to future computers relative to the ICL Atlas machine, one of the largest British computers to be manufactured. As we show in detail in Chapter Five of the report, general comparisons of the size and power of computers can be only approximate. Nevertheless, the comparison with Atlas is a useful indicator at this stage of the report.

The very large computer

64 A number of large computers of a power equal to 6–8 times that of Atlas has been designed and limited production on a commercial scale begun. Still more versatile computers having a power of 20–30 times Atlas are in an advanced stage of development and should be available in the first half of the 1970s. Computing power of this magnitude has been made possible by developments in electronics; the production of cheaper and more compact circuits; the availability of faster, higher capacity, immediate access storage and by significant advances in machine system design. Further increases in power, estimated at 50 times Atlas and more may become available between the mid- and late-1970s.

65 The economies of scale made possible by large computers have led to a ten-fold reduction in the hardware cost of computer processors in the last decade, and a continuing reduction is forecast for the next ten years but probably at a slower rate.

66 On the information available to us we assume that only US manufacturers will be able to supply these very large machines at the beginning of the 1970s. Existing machines are made in 'ranges' so that the processing capability of a machine may, during its life, be enhanced with the minimum of difficulty, and without the need to reprogram. If this feature is continued into new ranges to be developed later in the decade it must incline users to continue with equipment from the original supplier. In this situation, given both the need for compatibility between Government systems and general policy factors, it may not be possible for Government users to exploit on a large scale in the more immediate future the potential of the very large machine. Nevertheless, the possibility of their use in Government has to be considered carefully.

Operating software

67 Full realisation of the vast computing power represented by these large computers, and thus the cost benefits, depends on efficient operating software, efficient higher level programming languages, and other software aids. If a large number of programs is to be run concurrently with optimum efficiency – and if the sometimes simultaneous requirements of real time working and batch processing are to be satisfied – efficient operating systems are essential. Manufacturers have now begun to make progress in this difficult area and development is being facilitated by designing hardware to assume functions hitherto undertaken by software. Manufacturers have recognised the difficulty of designing efficient general operating systems, so efforts are being made to provide tailor-made operating systems for particular operating environments. This is an area in which there have been many set-backs, and much work remains to be done before it will be possible in practice to exploit to full effect the great power and processing capability of the very large computer.

68 On the other hand, continued development of operating software for machines smaller than the very large ones is expected to improve progressively their operation.

Programming languages

69 Hitherto, the price of using the higher level programming languages such as COBOL, ALGOL, and FORTRAN has been inefficient use of the computer.

Hardware and software being developed will reduce these inefficiencies. This will help users to deploy their systems and programmer staff more effectively in order to take full advantage of the new range of computers likely to become available. It could also help to reduce the demand for programmers. Specialist users are being catered for by the production of an increasing number of languages tailored to their requirements, and the development of more sophisticated report program generator packages is expected to enable more and more people without computer expertise to make use of the machine.

70 One of the advantages hoped for originally from the higher level languages was that they would enable the user to write programs in any given language which could then be run on any computer provided it was equipped with the appropriate compiler. This hope has not so far been fulfilled and seems unlikely to be realised in the immediate future. The development of the language PLI may eventually provide the best means of achieving some machine independence. But the language is controversial. Its future will depend in part on the demand for it and very much on whether manufacturers will produce compilers for it.

Other software developments

71 Three developments should contribute significantly to improvements in software production and performance:

(a) Some consultants are introducing systems to facilitate the testing and correction of the individual modules of large higher level language programs as they are written. This facility was largely lost when the higher level languages were introduced.

(b) Aids are being developed for monitoring the performance of programs under actual working conditions.

(c) The Technical Support Unit (TSU) of Mintech is pioneering a scheme for the type approval of software offered by the computer manufacturers. In the past it has been difficult for a user to satisfy himself that manufacturer-produced software will live up to the claims made for it.

Peripherals: general

72 Realisation of the full potential of the large computer depends, in addition to efficient software and optimum systems design, upon the efficiency of the input and output equipment, the capacity and type of the various levels of storage and the speed of access to that storage.

Magnetic peripherals

73 The magnetic tape, disc, drum and, to a lesser extent, magnetic card provide the computer with both its fastest means of input and output and also, for the time being at least, its high capacity backing storage. In general terms, no fundamental changes in peripheral equipment are expected during the first half of the decade. There will, however, be significant improvements in the data transfer rate of the magnetic peripherals, and in the total on-line capacity of disc backing stores. There will be a general improvement in efficiency and reduction in cost. Research at present being carried out into a wide range of

possible storage devices may eventually provide backing stores offering on-line access to billions of characters. A mass immediate access store capable of competing in cost with the magnetic drum, and offering a significant reduction in access time, is also being considered. If the research is successful these devices could be available in the latter part of the 1970s.

74 More specifically, the major development of magnetic peripherals is likely to take the form of improved recording techniques leading to significant improvements in information bit packing density. Thus:

(a) Tape decks capable of recording at twice the density of the high speed decks currently in use should be on the market within the next 4–5 years. Analogue recording techniques are also being developed which will allow for even greater packing densities. If these trends continue there is the prospect that tape decks offering data transfer rates of at least one order of magnitude greater than the fastest decks now in use will be available towards the end of the decade. The first of these developments is compatible with existing recording techniques and there should be little difficulty in using the equipment with existing computer systems. The second development is incompatible. There could be difficulty in using it with existing systems and special provision would have to be made for the conversion of existing standing files. Improvements in bit packing density may lead to cheap, low speed decks utilising slower and less costly mechanical tape movement systems.

(b) Developments in the mechanical design of tape decks will improve reliability and reduce tape wear. A growth is expected in the use of tape cartridges.

(c) Improvements in the bit packing density of discs and a modest decrease in access times are expected to result in the use for some applications of large fixed disc systems for on-line files well in excess of 1,000 million characters. Cost reductions of approximately 50–70 per cent are envisaged. The versatility of the disc as an on-line direct access device and the fact that it compares favourably with tape in cost terms for on-line storage means that it will tend progressively to replace tape as the main backing store. Tape will continue to be used extensively for archival storage and in support of direct-access devices (eg for 'dumping').

Other backing stores

75 Extensive research is currently being carried out in areas which appear to offer potential for the development of backing stores having immense capacities. These are all longer-term research projects with unpredictable outcomes but they could have profound significance for the scope of future computer applications.

76 As an example, the best known of these projects is the Laser-Hologram memory which has already been shown to be capable of recording at a density of 2 million bits per square inch. Development to three times this density may be possible. The snag with the Laser-Hologram memory is that it requires optical and mechanical systems of a very high order of precision and special environmental working conditions.

77 Other possibilities are magneto-optic memories, acoustic memories, and the use of low-temperature super-conducting devices.

Printing

78 Briefly, the speed of printers will increase as will their capacity to provide a larger range and variety of types of print. Print quality will be improved so that it may be read by machine (Optical Character Recognition). Relatively slow but cheap line printers may become available for use with large multi-access computer systems serving users wanting a high volume of printed output. Relatively high speed (20 characters per second) keyboard character printers are also being developed.

79 In rather more detail, mechanical considerations will probably place an upper speed limit of 3,000 lines per minute on the operation of the conventional, impact type, line printer. Printers with this performance should be available by the mid-1970s provided there is sufficient demand to justify their production.

80 Much higher speeds, five times as great or more, may eventually be available from non-impact type printers making use of chemical, electro-statistic, or other means for producing the print. These printers will reproduce a large variety of fonts including symbols and other shapes. A number of machines of this type are already in development but equipment and material costs promise to be high and print quality suspect. If these deficiencies can be overcome the non-impact printer may be used in Government installations, with possible savings in cost (staff, accommodation and equipment), during the latter part of the 1970s.

Data collection

81 The collection of data and its conversion to machine-readable form for processing by the computer has always been one of the weak points in the computer system. This process has normally meant punching data from the source document (frequently using a specially prepared punching document) by manual keyboard machines onto paper tape, punched card or, more recently, magnetic tape. Data preparation in this way accounts for approximately one half of total ADP staffs and is sometimes a bottleneck in the whole process. It is always an unsatisfactory but necessary procedure.

82 No major developments are expected in conventional punched-card and paper-tape preparation equipment. There is, however, a pilot scheme in prospect to use a small computer to control input from a number of keyboards and place it in mass immediate access storage for subsequent transfer to the computer. This procedure will probably be viable only where upwards of 30 data preparation staff are currently required. It could yield a 10% staff saving.

83 Strenuous efforts are being made to provide a generally effective means for reading source documents direct into the computer. Magnetic ink character recognition (MICR) has been invaluable to the banks in this connection for cheque processing. This technique is not thought to have general application because it is expensive and inflexible. The emphasis now is on the development of Optical Character Recognition (OCR) which is already in use in Govern-

ment. Advances which are expected include the ability of the equipment to read unformatted documents in typescript or letterpress in a mixture of different fonts, and the linking of the OCR equipment on-line to the computer. When this technique is developed it should remove the present bottleneck in data preparation and produce staff savings. Even so, not all applications will be suitable for handling by OCR.

84 Progress with voice input techniques is slow and we cannot say with confidence that they will be generally available to Government in ten years' time. On the other hand, the development of the key or touch-tone telephone by the Post Office may provide, in about five years' time, a facility for the cheap inputting of data in small volumes. The attachment of approved accoustic coupling devices to existing telephones will serve a similar purpose. This means, for example, that an official away from his office on some assignment will be able to input data direct to the computer from wherever he may be, immediately the data is obtained. A longer-term prospect in this field is the view-phone which would provide visual contact and the facility for inputting and receiving data at high speed.

85 Visual display units and electromechanical keyboard terminals which enable a user to communicate direct with the computer in a continuing or 'interactive' process are already in use. As the cost of visual display units comes down they will probably replace the less reliable, slower and noisy electromechanical terminal in many applications.

Small computers

86 At the other end of the scale of size from the very large computer we may expect continued development of small computers. Small computers are now becoming available at a low cost with the computing capabilities of what were large machines ten years ago. Some offer limited multi-access facilities.

87 The main advantage of the small computer is to make available computing resources at an isolated unit where there is only a relatively small computing requirement.

88 At this end of the scale, keyboard entry computers which have been or are being installed in a few departments offer the special attraction of visual hard copy of records.

89 Most small computers – and especially keyboard entry computers – are incompatible to a greater or less extent with larger machines. Their use in Government needs to be scrutinised carefully to ensure that a short-term financial benefit is not achieved at the cost of frustrating later demands for compatibility.

90 The development of independent small computers will obviously be in competition with that of remote terminals to larger computers. It is not yet possible to predict which trend will predominate, and Government should be prepared for both possibilities and any combination of them.

Data transmission facilities

91 The precise way in which computers will in future be used to maximum advantage will depend in part upon the facilities available for data transmission. For some processes where time is not critical the normal postal service or

possibly a van service may continue to be the most economical way of transferring data. But others, and certainly the computer networks which are now in prospect,[1] will depend heavily on the availability of adequate data transmission facilities at an acceptable cost.

92 The Post Office Datel services currently provide a variety of data transmission facilities and they will be further developed. The rate at which these developments take place, and their precise form, will depend upon demand. The Post Office is currently attempting to assess the probable size and significance of this. SCICON Ltd., a firm of consultants, recently completed a survey for the Post Office on demand.[2] Until their forecasts are considered it is not possible to predict the future in detail; but the requirements of Government are, on past trends, likely to form such a small part of the total that developments will be shaped by the demands of the private sector. The Post Office is satisfied that they will be able to meet this demand.

93 We do not consider that a fundamentally new type of data transmission facility will be available during the first part of the next decade. Indeed the SCICON report mentioned above does not see a need for such developments. But the possibility of developing a digital 'store and forward' message switching network is being studied by the Post Office following pioneering work at the National Physical Laboratory. This study is being conducted in parallel with one employing circuit switching and we understand that a decision will be taken next year on the implementation of a separate data network. The message switching network would probably take the form of a nationwide network of high speed digital lines (using Post Office facilities wherever possible) linking together a number of 'nodal computers' which would control the transmission and routing of data packages at very high speed within the network. The packages would be assembled by 'inter-face' computers linked on one side to the nodal computer, and on the other to individual terminals or systems of terminals. If either form of data network is adopted full implementation is expected to take at least another five years.

94 The cost of data transmission facilities is an important consideration. Line costs are related to distance and should therefore influence the planning of the areas to be served by particular networks so that the maximum effective service is provided for the minimum cost. The future cost of the facilities will respond to demand and depend in part on developments which this demand promotes. Future costs cannot therefore be predicted at this stage. But the Post Office are confident that costs will come down.

95 The computer network will link users with, and without, computers of their own. Those with computers will probably be using for their own local applications, including the validation of data for subsequent processing on the central large computers, one of the small, cheap but powerful computers the development of which has been stimulated by the advances in techology pri-

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[1] These networks may consist of a medium or large computer providing central facilities of various kinds – eg remote batch processing; remote access to a central data base, possibly requiring rapid response; time sharing – for a number of users some of whom may have their own computers for their local applications.

[2] Advanced newspaper reports suggest that the report concludes that the Post Office is in 'a unique and favourable position in data transmission which would enhance [the United Kingdom's] use of computing equipment and set an international lead in this important and prestige activity.'

marily associated with the very large computer. The user without a computer will require a terminal. Two forms of terminal in process of further development have already been described ie the touch-tone telephone and the visual display unit. On a larger scale the development of high capacity remote terminals for the input of data for subsequent remote batch processing has been in progress for several years and will continue. Recent advances include more powerful terminals capable of working at a transmission rate of 4·8 K bits per second. These terminals include line printer output facilities, card and/or paper tape input facilities. In some respects, terminals of this kind linked to a large computer provide the user with similar facilities to those he would obtain from an on-site computer under his own control.

Summary of prospects

96 During the next decade much larger computers will become available, initially (at least) from US manufacturers. They will provide massive computer power and, potentially, greater processing capacity at continually reducing cost. This reduction cannot at present be quantified. The trends will be matched by corresponding developments in peripheral equipment, particularly towards the end of the 1970s. This too will become cheaper and more efficient. The systems of the future will therefore enable the user to undertake tasks far beyond the capacity of present equipment. The present inefficiencies at the stage of data input will be reduced and equipment will become available which will enhance the versatility of the computer and encourage its wider application. Storage devices will have greatly increased capacity and the rate of data transfer will be significantly improved. The speed and quality of printers will improve and cheaper equipment will be provided to accommodate the voluminous output from multi-access systems. Data transfer facilities will be developed to promote the effective deployment of computers by the creation of networks and to put the computer at the service of an extensive and widely dispersed range of potential users. The cost of these data transfer facilities, too, should drop. At the lower end of the scale there will be a competing development of small computers, which will also be potentially capable of extending the range of worthwhile applications.

97 It is in the vital area of software that the rate of development may not match that elsewhere. This is critical because without it the full potential represented by the power and processing capability of the advanced systems cannot be realised. Improvements in operating systems are now becoming available, but the production of effective systems for complex applications, such as the extensive multi-access system providing simultaneous facilities from a common data bank for a number of users with different requirements, is unlikely to be a practical proposition for some years – some leading manufacturers put this development at upwards of ten years. Again, the slow and hesitant development of a standard high level language defers the desirable prospect of true machine independence. Improvements in higher level languages are, however, expected to increase the productivity of programmers, and to provide a means of access to the computer for an increasing number of people without programmer training. Finally, the value of software documentation standards has been recognised; and the type testing of manufacturers' software, the development of software measuring aids and the use of modular

programming are being actively pursued. They will promote a general improvement in software development.

Interdependence of technological forecasting and future requirements

98 Although for ease of description we discuss separately technological progress and the uses to which this is likely to be put in Government the two subjects are, and increasingly will be, interdependent. Thus the existence of more extensive, faster and cheaper computing facilities must influence decisions to apply computers to procedures where hitherto the application was neither feasible nor economic. Again, the availability of these facilities may promote new developments in Government which could not otherwise be undertaken. Conversely, the future requirements of the user, if anticipated and defined sufficiently far in advance, will stimulate research and development by the manufacturers and systems designers. Whether or not manufacturers find it worthwhile commercially to satisfy possible requirements will depend in large measure on the level of demand.

99 This situation has always prevailed in the scientific sector where computers are essential to undertake massive computational tasks and problem-solving which otherwise would be intractable or at least very time-consuming. Computers were invented and improved in response to these demands. Originally this did not apply to anything like the same extent in the administrative and general purpose data-processing field. The great majority of the early ADP applications – eg payroll, stock recording, invoicing and basic clerical tasks generally – were and still could be undertaken manually. The computer does the job more cheaply, faster or more efficiently and with fewer people; but it is not essential. Even in this field, however, many technological improvements have been stimulated by the requirements of the user (eg high speed printing).

100 The position is now changing. The use of simulation techniques to improve decision-taking demands extensive and high-speed computing facilities. So will the large-scale retrieval of information. In Government, schemes involving the speedy marshalling and processing of vast masses of data derived from several sources will not be practicable without similar facilities. They would otherwise require thousands of staff, who will not in any case be available; and be uneconomic.

101 In this situation there must be close contact between those responsible for planning, in consultation with the policy makers, ADP developments in Government; and the manufacturers. MS(C) Division, CSD, must therefore keep itself fully informed of the likely course of future technological developments. It must ensure, as far as the requirements of confidentiality will permit, that the future requirements of Government are made known to the manufacturers. A prime object will be to keep the options (in terms of the equipment to be used) open for as long as possible. This will minimise the risk of acquiring technically obsolete equipment, though the rapid rate of technological advance must mean that this object will never be wholly achieved.

102 One particular problem which will require attention is the fundamental incompatibility of the ICL 1900 series with other computer series, notably ICL System 4. We have not given any special study in our technological forecasting to this problem; but we recognise that, because of its substantial purchases of the 1900 series, Government has a considerable interest in how it is resolved. While this report was being drafted ICL Ltd did, in fact, announce that it is not going ahead with the projected 1908A. Instead the company intends to develop a very large machine on different design principles to be available some time in 1973.

Forecast of future applications

103 In the remainder of this part of the report we indicate the new applications for which computers may be used in Government during the next decade, taking into account the forecast technological developments. Where we can we indicate how applications are likely to depend on the advancing technology. MS(C) Division has given some preliminary thought to future applications but, apart from this, we have had difficulty in collecting the material from which to make our forecasts. Most departments are fully occupied with their current tasks and, except for one or two large projects which are at an advanced stage of planning, are giving little thought to possible longer-term developments. There is in fact a strong feeling in a number of departments that they must now have a period for settling down during which they can consolidate before embarking on still more ambitious ADP schemes. They are concerned about their limited specialist staff resources, and consider that priority must be given to the replacement and improvement of existing systems and not to the introduction of new ones. These are not the conditions for imaginative forward thinking.

104 We are not concerned here with the replacement of existing systems even where, as will normally be the position, this involves the refinement and perhaps the expansion of the original application. These systems are covered in Chapter Two. We deal separately in Chapter Four with those new applications such as the Business Statistics Office (BSO) and the Civil Service Personnel Record and Information System for Management (PRISM) which involve integration in some form with related developments in particular departments. A significant number of the new applications within MOD also appear in Chapter Four. Unavoidably this treatment has involved us in some arbitrary distinctions and, in a few cases, to references to the same applications in more than one Chapter of the report.

105 We distinguish as far as possible under two broad heads:

(a) Plans clearly identified by departments. In some cases the computer required has been identified: in some cases there has been no such identification. In other cases the application would probably make use of computers either installed or envisaged for another purpose.

(b) Longer-term and more remote possibilities only some of which have been envisaged by particular departments.

106 Where possible, we indicate when the new systems are expected to come into operation. This is virtually impossible with the longer term predictions.

These depend on so many variables including the outcome of feasibility studies and political decisions. All we can say is that if they are proved to be feasible, and provided the necessary staff are available to implement them, they all could possibly be in operation by the end of the 1970s.

CLEARLY IDENTIFIED DEPARTMENTAL PLANS

107 These are arranged alphabetically by department. We have put in brackets the classification of the application used in Chapter Two. Our reason for giving an extensive coverage of these applications is to illustrate the breadth of computing forecasted in Government.

Ministry of Defence

108 This is a difficult department to cover comprehensively under this particular head. This is partly because of the scale and span of its computing activities. Furthermore, MOD has now used computers for a relatively long time. Many of its plans are, therefore, directed to extensive improvements to and expansions of existing systems, and towards integration of systems. For convenience these applications are reviewed in Chapter Two and Four though some of them would merit inclusion in this Chapter. Two developments only, one major and one relatively small, are mentioned separately in this section:

(a) *Stores Systems:* A major centralisation is planned: the Navy on a large machine at Bath in 1971/72 mainly for control and provisioning for stores in the dockyards; the Army on an ICL 1906F in 1970 with a further 1906A in 1972/73; the Air Force on a very large installation at Hendon in 1971/72. ADP applications in the Defence stores field generally are likely to constitute a major area of work throughout the 1970s.

(b) *Training:* A medium-sized computer for research, war games and demonstration purposes is planned for the Royal College of Military Science at Shrivenham in 1970/71.

Department of Health and Social Security

109 (Social security collection and disbursement.): The earnings-related scheme at Newcastle-upon-Tyne is planned for full implementation over the period 1972/75 with two, and possibly three, ICL 1906As. This scheme will demand the rapid processing of very high volume files, and will therefore require a large number of high speed tape decks. If the first and pilot stage of the short-term benefit scheme, which is centred on Reading, proves successful plans are to extend it to three or four more regional centres over the years 1970/75. Each centre will probably require two ICL 1906As.

Home Office

110 (Special application.): A police records scheme is to be set up at Hendon to service police authorities throughout the country. It will initially include the records of stolen vehicles, finger prints, and wanted and missing persons. By 1972 the record will contain particulars of vehicle owners. This scheme will require a real time system providing access through remote terminals. Terminals will be installed at a rate of 150 a year, building up to a total of 700 by

1975. Powerful computers and a highly efficient operating system will be needed to service the network of terminals and maintain a large data bank. With the introduction of massive direct access stores the record itself could be expanded to include such things as a person's previous history. If, as we suggest in Part Four, this system is eventually to be incorporated in a law enforcement system, still more powerful machines will be wanted.

Inland Revenue

111 (Revenue collection.): The department plans to take on to the computers in the nine regional Schedule E (PAYE) Centres[3] some of the clerical processes associated with Schedule D (broadly the tax on self-employed persons), corporation tax and capital gains tax assessments. These computers will also assume some of the clerical and accounting procedures of tax collection. When the present computer at Worthing, which is used for payroll and statistics, is replaced in 1972 (probably by an ICL 1904A) it will also undertake some surtax procedures and the reconciliation of all IR payable orders.

Lord Chancellor's Departments

112 *Land Registry:* (Information retrieval.): It is proposed to transfer the registration of land charges to computers in 1972. This work is currently undertaken by 300 executive and clerical staff at Kidbrooke.

Ministry of Transport

113 (Special application.): A scheme for the registration of vehicles and driver licencing is being set up at Swansea. The take-on of work is planned to commence in 1972 and the system should be fully operational by 1976. The initial computer requirement is for two ICL 4/70s. The growth in the volume of work to be undertaken by this installation at Swansea, possibly extended to include other areas of work, will generate a need for substantial increases in computing power during the second half of the 1970s. An advanced system of this kind will also require large numbers of high speed line printers.

LONGER TERM POSSIBILITIES IN PARTICULAR DEPARTMENTS

Ministry of Defence

114 (Special application – stores.): The possibility of using computers, in some cases on a bureau basis, for non-operational movements work, and for operations and intelligence, is under consideration. The full development of the centralised Air Department stores system at Hendon will be improved by the further development of remote terminals and will depend critically on the provision of advanced operating systems.

Department of Employment and Productivity

115 (Special application.): The department is planning a pilot scheme in about two years' time, which will run for three years, to test the feasibility of match-

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[3] East Kilbride 1968/70; Bootle from 1971; Cardiff 1973/75; Shipley 1974/75; Manchester 1975/77; Washington, Co. Durham 1975/77; Edinburgh 1977/79; Portsmouth 1977/79; Midlands (location to be determined) 1977/79.

ing by computer employment vacancies with persons seeking employment. For this experiment about 16 terminals in local offices will be linked to the department's ICL 1904F at Runcorn. If the computer-based system proves to be more effective than the manual one a national network based on an expanded computer complex at Runcorn could be introduced within the next 10 years. The department also hopes in the late 1970s to organise and control the work of an expanded Factory Inspectorate with the aid of ADP. The application would probably require rapid response facilities from a large installation.

Foreign and Commonwealth Office

116 (Information retrieval – special application.): One of the uses to which a computer system in this department might be put is the application and issue of passports. Others include finance (eg management accounting) and cataloguing.

Department of Health and Social Security

117 (Social security collection and disbursement.): When in full operation the earnings-related scheme will require computer power estimated to be of the order of 8 times Atlas. If in due course this system is to be integrated with other of the department's major ADP activities at Newcastle even more powerful computers will be necessary. It seems likely that the production on computers of pension order books will become more economic if, at the end of their useful life, the present battery of high speed line printers at Newcastle is replaced by a smaller number of the very high speed printers which we forecast.

Home Office

118 *Command and control* (Special application): An experimental police command and control system may be set up by the Home Office in Birmingham, probably in 1970, with the cooperation of the city's police force. Essentially a command and control system is concerned with the inward transmission of information, including details of the disposition of police officers and vehicles, to a central point; and with the assembly and processing of this information so that decisions can be taken and operations controlled. If the pilot scheme is successful it could be developed into a national network.

119 *Police and prison stores* (Stores): The Home Office recognise that this is a suitable subject for a computer-based application. It may follow from the regionalising of prison stores and involve data links with a central computer.

Lord Chancellor's Departments

120 *County Courts Branch* (Accounting, record keeping and statistics): The possibility of using computers for recording judgements, accounting for money paid into county courts by debtors, recording and accounting for money held on behalf of beneficiaries, and associated statistical work, has been proposed. This work at present occupies more than 500 staff in 300 offices in England and Wales. A computer system to service this organisation would

probably require a data network linking the local offices to a central computer. Its feasibility and justification are clearly dependent on the technological developments we have reviewed.

121 *Land Registry* (Information retrieval): The possibility of using computers for registering land titles is being considered. This application would make use of the grid coordinate reference technique now under review by General Register Office (GRO) and MHLG. The registration work is currently undertaken by 3,900 staff in nine district registries.

122 *Public Trustee Office* (Accounting: Banking and savings): A preliminary study has been made of a system for computerising the accounting and investment activities connected with the 13,000 trusts handled by the Office. If approved this system would take about five years to introduce and is expected to save about 100 staff. If successful, it might be extended to the Supreme Court Pay Office.

123 *Royal Courts of Justice* (Special application): A system making use of a computer for translating directly from steno or palantype keyboard to printer is being developed at the National Physical Laboratory. This is of interest to the Committee on Tape Recording in the Courts.

Department for National Savings

124 *Premium bonds* (Banking and savings): The feasibility of computerising some of this work, which occupies about 2,300 staff, is under review. A computer-based system could not come into operation before 1975/76.

125 *Save as You Earn* (SAYE) (Banking and savings): This scheme will initially be operated manually. An ADP system will be developed if the scale of business warrants it, and could save about 200 staff. The department estimates that it would take about two years to introduce a simple ADP system which could subsequently be refined and expanded.

HMSO

126 *Bookselling and publishing* (Information retrieval – special application): The department would like to develop an integrated system which would record data for the control of all aspects of this work, eg cataloguing; codification; indexing; selling.

127 (*Stores*): There is considerable scope in HMSO for the development of an integrated computer-based stock control, inventory and accounting system (eg as in MPBW); and for integrating payroll with works costing (eg as in MOD).

128 *Typesetting* (Special application): The department has also considerable interest in the use of computers as an aid to typesetting.

Board of Trade

129 *Exports Services Branch* (Information retrieval): At the present time ESB collects and disseminates information manually about export opportunities. It is proposed to supplement this with an intelligence service to 4/5,000 subscribers, matching export opportunities against known suppliers of commodities. This service would come into operation in 1970/72 using the Business

Statistics Office (BSO) computer at Eastcote. It might be expanded at BSO Newport after 1972 by the creation of a data bank of information about export commodities.

130 *Patent Office* (Information retrieval): The possibility of processing and examining patent applications is being considered. Some of the simple operations could be computerised by 1975: computerisation of the more difficult search problems associated with examination will depend on general progress with the techniques of information retrieval.

Ministry of Transport

131 *Driving test bookings* (Special application): At present bookings for driving tests in the Metropolitan area, which represent one fifth of the total bookings for the country, are computerised. A centralised scheme for the whole country is regarded by the department as a long term possibility. This work could be assumed by the Swansea computer. The 80 local licencing offices which will remain after the vehicle registration and driver licencing schemes come into operation could serve as application points.

FUNCTIONS AND TECHNIQUES

132 In addition to these possible applications of a specific nature in particular departments there are a number of functions and techniques which spread across many departments. Some computer applications are already concerned, to a limited extent, with these functions and techniques. It is convenient to review them together because many of them are closely associated with the technological developments forecasted at the beginning of this Chapter.

Accounting

133 At the present time only four departments – MAFF; Customs and Excise; MOD (Navy);[4] MPBW – have computerised Vote accounting systems.[5] Two other departments (DES and MOT) propose to computerise their Vote accounting systems by 1971; and the Home Office intends to do so when it has prepared computer programs for bill paying. All the remaining departments use accounting machines or have manual systems.

134 Potentially, therefore, accounting would appear to be a suitable field in which to extend the use of computers in Government. It would also appear from commercial experience to be a normal progression from accounting machines. The Paymaster General's Office (PGO) has suggested that this could lead to a useful standardisation of accounting procedures in departments and, possibly to the computerising of its 'Vote watching' function. The use of ADP for implementing the Vote accounting system of a particular department could

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[4] We deal with the further computerising of MOD Vote accounting in considering integration in that department (paragraph 197).

[5] Vote accounting may be defined as a precise cash accounting system whereby Parliament approves annually the appropriation of funds on the basis of departmental estimates. It can be distinguished from management accounting – ie the preparation of data in various forms useful for the purposes of management – control of monetary expenditure; appraisal of past performance; forecasting policy formation. Output budgeting is a form of management accounting. With management accounting precise accuracy in the figures is neither possible nor necessary.

be achieved in one of three ways:

(a) As a separate project. This will depend on whether such a project can be justified on cost or other grounds (we deal with justification in Chapter Seven).

(b) As part of an integrated computer system designed to include, for example, procedures for payroll, bill paying, stock control etc.

(c) In the course of developing a computer-based management accounting system. The stewardship of a cash account for Vote purposes will be difficult to integrate with a management accounting system. For example, it distinguishes neither in terms of time nor of capital expenditure and takes no account of debtors, creditors or stock. In these circumstances the only realistic way of proceeding might be to concentrate first on the development of the management accounting system and the provision of output data required for Vote accounting purposes.

135 We assume that, in most cases, it will be sensible to combine the computerising of Vote accounting with other developments as in (b) or (c) above. Much will depend on the stage reached in particular departments with projects of these kinds. We do not consider that the same system will be suitable for all departments, or even for all branches within a big department. We are therefore of the view that integrated accounting systems will be developed and operated on a departmental basis; though they must obviously provide in a prescribed form information required by any central financial management system (see paragraph 245(d)).

Decision taking

136 Computers will almost certainly be used increasingly in all departments over the next ten years to provide information for high level decision taking in the fields of management and policy. Two examples are:

(a) Computer-processed network analysis (time and resources).

(b) Model building and simulation studies, eg the development of a health service system; economic and fiscal planning (the latter through the development of a tax model); urban planning.

137 Management decision-taking assisted by computers is a complex operation involving the simultaneous consideration of a very large number of variables, frequently inter-related. Development of the models will have to be undertaken by OR specialists, economists and statisticians, and ADP staff in close consultation with senior management. It is frequently suggested that senior management will need to communicate directly with the computer through desk-top terminals of some kind. It is relevant in this context that at least one large commercial concern which uses computers intensively believes this refinement to be a waste of senior management's time. Dr H Grosch, director of the centre for computer sciences at the National Bureau of Standards, Washington, DC, is also on record as saying that 'conversational' computing on these lines has limited use outside specialised applications (eg university instruction; airline reservations).

Operational research

138 Operational Research (OR) techniques – eg linear programming – are

of particular significance as an aid to decision-taking. Operational Research originated in Defence and MOD are the leaders in this field. Increasingly, many other departments, with Management Services (Operational Research) Division of CSD acting in a central coordinating and advisory role, are using OR techniques, often aided by computers.

Casework

139 The big staff savings from data processing in Government have so far been achieved in the clerical (including clerical assistant) field by computerising relatively straightforward and repetitive departmental work processes (eg preparation and issue of documents; maintenance of up-to-date records; arithmetical calculations; payroll) which, when undertaken manually, require large numbers of staff. MOD, DHSS and IR have already saved, or will save, large numbers of staff in these ways. So far serious attention does not seem to have been given to computerising the better quality case work at clerical officer level and above which involves the application of case law, regulations or settled practice. This considerative function involves selection from a number of possibilities and hence the exercise of judgement.

140 Dealing with complicated exceptions may require hundreds of computer instructions to implement each aspect of a procedure. This imposes a high cost in terms of programming effort which may not be available when staff resources are limited. Moreover, it means that fundamental changes in the computer system cannot be achieved at short notice. This could be highly inconvenient where changes in a system are imposed by legislation and have to be implemented quickly; especially where it is not possible to give the programmers the period of advance notice they must have to meet requirements.

141 But limited progress is being made. The PGO has recognised that it can computerise some of its casework for pension payments. To achieve this would, however, require considerable staff time for systems and programming development; at present the department has none to spare from the main run of the work. In designing the short-term benefit scheme at Reading, DHSS is aiming to cater not only for the straightforward work which accounts for the bulk of clerical effort, but also for the more difficult cases amounting in number to 10 per cent of the total. This has increased the burden of the programming work disproportionately and added considerably to the difficulty of getting the scheme off the ground. In retrospect, the department considers that it might have been better to have provided initially for these relatively few difficult cases to be handled manually rather than to provide complex programs for them.

142 Generally, therefore, we expect that in the shorter term existing computer systems will be modified to take on relatively simple levels of case work and leave the more complex cases for manual processing. In each instance the decision will depend on the specialist staff available to carry out the work, the cost of programming, and any statutory limitations which inhibit the simplification of procedures in such a way as to make them more amenable to computer processing. We do not consider that this prognosis will be changed materially by any of the technological developments which we have forecast. As a longer term possibility, attention might be given to recasting the whole

system so that much of the case work can be processed efficiently on computers. Certainly any new schemes which are proposed should be carefully considered in this way. This will demand close consultation in the formative stages between policy makers and senior ADP specialists. We must make it clear, however, that, in our view, Parliament is never likely to approve procedures which best meet the requirements of the computer to the detriment of the wider interests of the State and public.

Information retrieval

143 Several of the future applications in particular departments have been classified as information retrieval. We mean by this the collection, abstraction, classification, indexing and storage of information, frequently in textual form, which can then be retrieved and disseminated in response to enquiries. We do not include management information systems under this head: they are dealt with separately in Chapter Four. The availability of stores of immense capacity, coupled with developments in hardware store organisation and the production of advanced search programs, is essential to the development of effective information retrieval systems. The increased speed and greater flexibility of the non-impact printer will improve the reproduction of retrieved textual matter and speed dissemination.

144 Developments in three areas appear to have particular significance for Government:

(a) *Filing and registry work*

  (i) A significant part of the routine work in departments consists of the storage and retrieval of all kinds of information. The feasibility, and cost, of substituting a fully mechanised system for the physical storage of files of documents and the use of paper as a medium for internal communication in Government, has not so far been considered in detail. It will give rise to some formidable problems and we would not look for much progress in this area before the latter part of the 1970s.

  (ii) The mechanisation of registry work requires efficient indexing and the rapid retrieval of the filed information. The setting-up of a multi-access computer installation to meet the indexing needs of several departments, including the provision of extensive cross reference facilities, has been proposed as a possible line of development.

  (iii) A multi-discipline project team has been formed within CSD to examine these and other possibilities in some detail. The computer hardware to service developments of this kind will become available over the next few years, but we think it unlikely that much progress will be made in under a minimum of five years.

(b) *Collection, storage and dissemination of other information*

  (i) *Scientific:* Most scientific and technical staff have difficulty in keeping up-to-date with information in their particular speciality. Mintech and DES therefore have a major interest in information retrieval in this particular field. Mintech has formed an inter-departmental working party, which includes representatives from MOD, DES and CSD to consider the problems involved. Mintech is also engaged on a specific project to build up banks of technical and scientific information in particular fields of activity – eg atomic materials; electronics; machine tools. The initial feasibility study is occupying seven staff. The overall time-table for collecting, abstracting, indexing and classifying the information, and in making it available on-line through a computer network, is put at well over ten years.

(ii) *Intelligence:* There may be scope for comparable developments to those in the scientific field in the general administration and management of Government, particularly in the economic sector.

(iii) *News Service:* Central Office of Information (COI) and other specialist groups in Government might wish to develop computer-based news services. For example, in West Germany the Central Press Office is developing a computer-based system for the collection and dissemination of news items of a political, economic, and social character on behalf of Government departments and Parliament. The information stored will include a general heading, key-words, and an abstract summarising the essential facts. Access will be by visual display unit with 12 terminals working to the data bank. The computer will correspond in size to an ICL 4/50. The system is being developed by a project team of 24 people.

(c) *Libraries.* The Dainton Committee[6] has predicted that, within two or three decades, the larger libraries, laboratories, and industrial firms will be directly linked through their individual computer terminals to the computerised catalogue of the nationalised libraries. It envisages that computer storage capacity will begin to be able to cope with the retention of full texts of the world's literature. Computers will then be able to process the stored texts in response to particular queries and, if necessary, to display the results remotely by facsimile transmission wherever it is needed. These techniques might be applied within Government in the larger departmental libraries such as those of the Lord Chancellor and the Board of Trade. This sort of application is likely to require considerable staff. It has been estimated, for example, that a full study of computerised cataloguing will take seven to eight years and occupy upwards of 20 top-class computer specialists.

145 We regard information retrieval as a most important field for future computer development within Government; it is potentially one with a valuable yield in terms of efficiency and in some cases (eg filing and registry) of staff saving. But progress initially is likely to be slow even though, in some techniques, a great deal of work has already been done. It will also be demanding in terms of high quality specialist staff drawn from a number of disciplines, though the number involved will be less than for the full development of management information systems. It is essential, therefore, that departments pool their resources. The experience in Mintech and DES (ie the Office for Scientific and Technical Information, and its Documentation Processing Centre) of the organisation and manipulation of large files of data, including the development of search languages, should be available to Government generally. We also recommend that developments in this subject should be reviewed on a Service-wide basis so that any necessary priorities can be set.

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[6] Report of the National Libraries Committee, Cmnd 4028.

Computer-aided instruction

146 Computers are now being used experimentally outside Government, both in this country and abroad, in a variety of learning situations and in curriculum development. By connecting terminals to a remote computer the machine can be used for programmed learning and self-testing with the added advantage that the computer's potential can be used for monitoring the student's progress and tailoring the course material to individual requirements. We understand that developments of this kind in Government will be considered by Mintech and DES, in the light of the feasibility study sponsored by the National Council for Educational Technology.[7] They could conceivably include the training of specialists such as systems designers and programmers, new entrant training generally, and the instruction of staff in new legislation and procedures.

Computer-aided design

147 Mintech is sponsoring the technique in Government and has provided for its development in the independent forecast of its future requirements. MOD (eg Ship Department), MPBW (building design), BOT (civil aviation) and MOT (highway engineering) also plan developments in this area. Reductions in the cost of graphical visual display units (ie units with a vector capability); the growing ability of printers to reproduce graphs and create drawings; and the further development of graph plotters and photocopying equipment should offer improved facilities in this field.

Process control and numerical control

148 The use of computers for process control and numerical control is very largely the province of Mintech. Again it has provided for these in the forecast of its own computer requirements.

Scientific computing

149 We have already in Chapter Two dealt with the expansion of computers for scientific purposes in Mintech and MOD (including the Meteorological Office); these two Ministries dominate the use of scientific computers. Other departments have more modest requirements. Scientists have a special interest in the development of very large computers. The development of relatively high-speed keyboard character printers with a large character repertoire will also be of particular value to the scientific users.

Multi-access computing

150 The most pervasive of all possible developments is the use of multi-access computing. The technological advances which are expected also have significance for the development of extensive multi-access systems of the kind to which we have already referred, and for the provision of bureau facilities. Large time-sharing systems with many remote terminals can only be imple-

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[7] Computer Based Learning Systems: A programme for research and development, National Council for Educational Technology, 1969.

mented effectively by a large central computing complex. We expand on these possibilities because they concern the whole pattern and form of Government computing in the future.

151 The very large computer may be used as in the case of the Meteorological Office primarily for a single dedicated purpose, either because of the economies of scale which it achieves, or because a small computer could not cope with the task. Given an effective operating system, the computing power of the large computer backed by very fast high capacity immediate access storage, and supported by a range of high speed peripherals, offers greater efficiency than is normally possible with an aggregation of smaller machines.

152 The very large computer may, on the other hand, be provided for a number of users either on its own, or in conjunction with several smaller local computers operated by some of the users. In both cases a large computer is said to provide multi-access facilities. As commonly used this term covers real time systems; time-sharing systems; and systems requiring rapid response as used for interactive program development. An explosion of multi-access systems in the United Kingdom is frequently forecast. The provision of effective, cheap data transmission facilities would unquestionably stimulate the development of networks. In the scientific field Mintech is currently considering the feasibility of a departmental network based on several large computer installations. Most of the small establishments would then be connected to whichever centre most conveniently meets their respective requirements. Networks of this kind, which would provide both for central and some local computing power and allow for load sharing, appear to offer the most flexible, efficient and economic way of meeting the extensive growth in demand for computing facilities which the department anticipates over the next decade.

153 Dedicated networks are also in being or proposed for the MOD (Air Department) centralised stores system at Hendon; for the DHSS short-term benefit system centred initially on Reading; and for the Home Office police records system.

General development

154 Notwithstanding these trends, we are unable to conclude with certainty that the future of data processing in Government lies inevitably and comprehensively in large, centralised multi-access systems; or in computer networks.

155 The development of large multi-access systems has so far been slow and there have been many setbacks. In particular, many users have found the software provided by the manufacturers inadequate. As we have already indicated, some manufacturers do not expect to be able to provide within ten years or so effective operating systems adequate to control the most advanced and complex multi-access systems; and more than one authority has expressed the view that the software requirements of these systems are currently beyond the capacity of the most expert programmer.

156 There may also be strong opposition from individual users to committing all their work to a very large, shared, central computer, particularly when they require computer power for time-critical operations. There are real problems here, not predominantly of a technical nature. The user may have difficulty in shaping his procedures and fixing his timetable to fit in with the central

system and its scheduling arrangements. Past experience in a number of departments has indicated that where a user shares time on the computer of another department, it is the work of the computer owner which gets priority. The consequence of breakdown or disruptive action affecting a large central computer may be more widespread: the current limitations on core-to-core transfers over distances preclude rapid load shedding over networks in the event of trouble. There may also be strong political arguments against extensive centralisation on a large computer.

157 This catalogue does not imply that multi-access systems using very large computers, and computer networks, will not come to play an important part in Government computing. The implementation by hardware of some functions hitherto undertaken by software may, for example, eradicate some of the technical difficulties. At first, progress will probably be made within the bigger departments which have extensive computer requirements. Departments with spare capacity on large machines will also continue to carry out some jobs on behalf of other departments. But it will, in our view, be a long time before extensive data processing tasks associated with the major functions of particular departments will be undertaken on one very large computer operated jointly by or on behalf of two or more departments.

158 The introduction of multi-access systems will have to be carefully planned and costed in the light of closely defined and realistic objectives. The balance between central and local computing, and between the size of central and peripheral computers, will vary from case to case. It will depend on the particular requirements of the users: the response time required; the peak loads; the nature and the volume of the data to be processed and the nature of the processing. In some circumstances the best course may be to concentrate work of a similar kind on particular computers in order to make the most effective use of the equipment. In others, the availability of small, cheap and powerful computers on the one hand, and the cost of data transmission on the other, will provide a strong case for a separate machine at a particular establishment. This may be completely independent or alternatively it may be linked with a larger central computer.

159 This will place a great responsibility upon those responsible for computer planning both in departments and centrally. Departments will have to make appraisals on the lines we have described whenever a computer system is installed or replaced. MS(C) Division, CSD, must coordinate these activities. Techniques of appraisal must be developed and propagated. To do its job properly MS(C) Division must be kept fully informed of developments in scientific computing. If work is to be shared there may in certain circumstances be no good reason why a multi-access system should not serve both administrative and scientific users.

160 MS(C) Division must also participate in the planning and introduction of networks. The area which can most effectively be served by a network will depend on a detailed appraisal of the economics of the system, taking the number of users, the volume and nature of the anticipated traffic, and the cost of data links into account. It may be found, for example, that regional groupings provide the right answer for Government bureau facilities so that communication capabilities can be provided at minimum cost. Central planning is

essential to ensure that networks are used to the maximum and duplication or overlap avoided.

Computer bureaux

161 Somewhat similar considerations to those which influence the general development of multi-access systems and networks in Government will determine the extent to which bureau facilities are provided and how these are used.

162 Two general bureaux are already offering facilities to Departments: the Central Computer Bureau (CCB) operated by HMSO from Norwich and the Scottish Office Computer Service (SOCS) in Edinburgh. There are other developments in prospect. For example, MOD plan to install a large computer (ICL 1906F) in London to provide bureau services to directorates and divisions, and eventually to serve as the apex of a computer-based management information system. The computer at the Road Research Laboratory is intended to serve as a bureau for MOT.

163 Thus there is clearly some need for bureau facilities in Government and this may be expected to expand. In the year to 31 March 1968 over £500,000 of work including programming was put out to commercial bureaux: this is equivalent to the work load for two medium-sized machines. MPBW have indicated that they would be prepared to use regional Government bureaux for their regional work, and BOT would use bureaux for such tasks as accounting and research projects. Applications of the kind under consideration for the Lord Chancellor's Department might also be undertaken most effectively by a bureau. Generally, we are in no doubt that if a department is going to share time on a computer installation as a regular practice, it would be much happier to use a properly organised bureau, independently controlled, than it would be to make use of spare capacity on another department's machine.

Future development

164 The formation of further Government bureaux should be preceded by intensive 'market research". This examination in depth of the potential market will involve detailed analysis of the nature and volume of the work. Decisions must be taken on whether the work is appropriate to a general bureau (like CCB and SOCS) or to a special bureau dealing only, for example, with accounting processes or payroll and personnel. Prospective jobs will have to be costed, partly as a control on the customer department so that it can decide whether or not a particular job is worthwhile undertaking by bureau computer, and also as a check on the efficiency of the bureau itself.[8]

165 The location of additional bureaux should depend on the geographical location of the work load so that the most effective and economical use can be made of data transmission links. The majority of bureau users, in the commercial sector as well as in Government, see practical advantage in having the service close to hand. We hope that these important factors will be taken into account along with any dispersal considerations.

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[8] SOCS is already using a system for these purposes which could serve as a model for a more highly developed costing procedure.

Control

166 For reasons on which we expand in Chapter Six we do not favour the hiving off of Government computing to an external agency. This applies to bureau working as well as to other aspects of computing. Nevertheless, if it is accepted that general bureau working has a continuing place in Government, and if it is decided that this should be carried on by a separate bureau service, the case for using NDPS for this purpose will have to be carefully examined. An important consideration will be on the other pressing demands upon Government's limited computing resources. Such a move would, however, be strongly opposed by the staff associations. It would be more costly: it might prove less flexible in its response to Service requirements, and a certain measure of control over its own activities would pass out of the hands of the Government.

4 Integration

167 Our terms of reference direct us to consider the scope for the integration of the longer term requirements of Government for computers in one comprehensive plan. We have regarded this as the central and probably the most important single feature of our remit. Integration requires the adoption by departments of standard codes, classifications, data formats and terminology. It demands certain levels of compatibility between computer installations. The nature and extent of integration will in large measure shape the hardware requirements of Government over the next decade and influence significantly the development of the associated software. It will therefore have an important impact upon specialist staff requirements. It cannot be achieved without effective coordination and control of computer development throughout Government in association with developments in the rest of the public and parts of the private sector. It must accordingly influence the general organisation of computer effort in Government, both centrally and in departments.

Kinds of integration

168 We have considered integration under two broad heads. Firstly, we have looked at the extent to which data is exchanged, or may come to be exchanged, between departments and with external organisations. This is a basic form of integration. It does not necessarily involve the integration of separate computer systems and associated procedures, which we have therefore examined separately as a second more advanced form of integration. We have tried to assess the scope for functional integration of this kind across the whole span of Government, making use of information obtained from our discussions with departments or available in CSD. In addition to this general survey we have paid particular attention to developments in three large departments, the Ministry of Defence (MOD), the Department of Health and Social Security (DHSS) and the Inland Revenue (IR), the first two of which may be said to have a 'federal' structure. We have also examined the progress made in the development of integrated computer systems in the field of Government Statistics, following the reports of the Estimates Committee in 1966[1] and of the Advisory Committee on Computers in 1968. Finally we have considered as a separate and important aspect of integration the prospects for the formal development within and between departments of computer-based management information systems. We report separately on these special studies.

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[1] Fourth Report from the Estimates Committee, Session 1966/67 on the Government Statistical Service.

TRANSFER OF DATA

169 The exchange of data in machine readable form between branches of departments, or between departments, or between departments and external organisations is already beginning to take place and should expand rapidly. At the moment it is achieved primarily by the physical transfer of the medium holding the data, eg magnetic tape, from one installation to another. Increasingly it may be achieved by the direct exchange of information between computers over data transmission lines. An example of internal transfer within a department is the provision being made in DHSS for the exchange in due course of information between the two big systems at Newcastle-upon-Tyne and the four or five regional centres of the short-term benefits scheme. The range and scale of inter-departmental transfers and exchanges with external organisations may be judged from the following summary of developments which are either taking place or are in prospect over the next few years.

Department of Education and Science

170 The department proposes to establish a full record of students moving through the higher education system and into employment which will depend on information from educational establishments, eg technical colleges and universities and from the former students when in employment.

Department of Health and Social Security

171 The short-term benefit scheme will involve the transfer of data between some local offices of DEP and the regional computing centres of DHSS. Externally, the department is already in touch with employers about the transfer of information on earnings and contributions in machine readable form. For the future, the earnings related scheme will involve exchanges with the insurance companies on individuals 'contracted out'.

Home Office

172 The police records system at Hendon will receive information on vehicle registrations directly from the MOT vehicle licensing system at Swansea.

Ministry of Housing and Local Government

173 Information is required from local authorities for the calculations involved in determining rate support grants to local authorities.

Inland Revenue

174 Information on employees' earnings and graduated contributions will be passed to DHSS, Newcastle-upon-Tyne, from the nine regional Schedule E Centres. The department is also negotiating with employers, including other Government departments, on the transfer of information on earnings and tax in machine readable form.

Lord Chancellor's Departments

175 The Public Records Office (PRO) will have to store records produced on

the computers of other departments. This gives rise to technical problems over the appropriate method for storage and will involve standardisation between departments on the form of the records to be held by PRO.

Department for National Savings

176 Data will have to be transferred from post offices throughout the country to the central computer-based record at Glasgow. The department expects that, within 10 years, this will be achieved by direct communication between local post offices and the computer.

Paymaster General's Office

177 Banking reconciliation work on payable orders presented by the clearing banks involves transfers from the majority of departments, particularly MAFF, DHSS, MPBW and (eventually) MOT. The department is also in contact with the Committee of London Clearing Banks and the Bank of England.

HMSO

178 As a longer term prospect HMSO expects that statistical information will be received in machine readable form for direct incorporation in publications.

General Payroll

179 Departments, either individually or through the integrated Personnel Record and Information System for Management (PRISM) when established (see paragraph 245(e)), will exchange information on payroll with the clearing banks. The ultimate extent of this contact will depend in part on the success of schemes for the electronic transmission of funds now under discussion by the banks.

Conditions for data transfer

180 The exchange of information in these ways between independent systems is greatly facilitated where data is coded, classified and organised in standard form. It is easiest where the computers are compatible. Data transfer is not impossible where these conditions are lacking, but the cost of providing special software, and possibly hardware, for conversion purposes can be heavy (see Appendix I).

181 At the present time there are no mandatory standards for data transfer in the United Kingdom. Within Government, however, the efforts of Treasury OM2 Division (now MS(C) Division CSD) have ensured that most departmental ADP installations can process data recorded to a British Standards Institute specification on ½ inch magnetic tape. In particular fields of activity other departments have developed standards for their own purposes. For example, the PGO has prescribed standards for data transfer in connection with its reconciliation work. Again, a number of departments are agreeing standards with external organisations, although none of these yet involves transfer of

data in machine readable form: eg:

(a) DES has produced a computer-based common classification and coding system for all items affecting teachers' records, and their departmental handbook has been accepted by the local education authorities.

(b) MHLG, in consultation with other departments and representatives of the local authorities, is in the process of producing a standard set of definitions and codings for all financial statistics common to local government.

(c) DHSS (Health) is developing standard terminology, record format and programs in the field of medical records.

182 If maximum advantage is in future to be taken of data transfer facilities:

(a) General standards for the exchange of information need to be developed and adopted. The efforts of the United States Government are an example of what can be achieved in this way.[2]

(b) Machine compatibility, possibly of a limited kind, should be aimed for in particular fields of activity. For example, the development of links between DHSS, the London Clearing Banks and PGO will be made easier because, fortuitously, all three will be operating with ICL System 4 computers. In future such useful correspondence should not be left to chance when it might be ensured by advanced planning and consultation.

(c) Departments must coordinate their negotiations with external organisations on data transfer. We discovered, for example, that departments were independently exploring separate approaches from employers about the exchange on magnetic tape of details of employees' pay, tax and insurance contributions. Separate development in this way can only lead to duplication of effort and confusion.

183 We consider that MS(C) Division, CSD, must exercise a coordinating role in matters of this kind as part of its central planning function. It must certainly seek the development of general standards for data interchange and coordinate the work of other departments in particular fields to make sure that this is pressed ahead systematically.

INTEGRATION OF SYSTEMS

184 This form of integration may be defined as the integration of separate computer systems and associated procedures. At its simplest level the integrated system may take the form of a central data bank of basic information (eg names and addresses) which can be drawn on for separate use subsequently by a number of users. At the other end of the scale the integrated system may involve the manipulation and interrogation of large volumes of data common to several applications on behalf of a number of users, each of whom may concurrently be making different demands on the system. One object in designing a system of this kind is to ensure, wherever possible, that information is fed only once into the computer. Whatever action is necessary on this information is then taken automatically. This is known as the 'one-shot' approach. An integrated system must be distinguished from the use of computing facilities by a number of branches or departments for processing their own data

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[2] See, for example, the Federal Information Processing Standards Publications issued by the US Department of Commerce/National Bureau of Standards.

exclusively for their domestic purposes. We have discussed this already in Chapter Three.

Organisational and technical difficulties

185 The setting up of a large and complex data base with one set of records which can be accessed on demand by a number of users with different requirements presents some serious problems. The user will have difficulty in organising information on the record in order that it can serve effectively several purposes possibly with different time cycles. On the technical side the manufacturers' own prophecy is that it may take the best part of ten years to produce reliable error-free software for the more elaborate integrated systems. This seems to put the development of massive fully integrated systems serving more than one department (or more than one branch within a large department) from a single record beyond the ten year time span with which we are primarily concerned.

186 For example, DNS sees no prospect in the foreseeable future of establishing one computer-based record for each person with whom it deals, covering the Post Office Savings Bank, premium bonds, the contracted savings (SAYE) scheme and, possibly, savings certificates. It is considered that the size of the record, and the cost and complexity of updating and accessing it, will rule this out as a practical proposition.

Portents of integration

187 Our general review of departments, which takes into account the information obtained on our visits, has brought to light comparatively few indications of systems integration either within Government or with external organisations. As the following summary shows these are limited in scope and lie mainly in the future. This summary is classified under broad subject heads. It excludes applications in MOD, DHSS, IR and statistics, which we cover separately in paragraphs 192 to 230 and also management information systems (paragraphs 231 to 251).

(a) *Common data bank:*

- (i) *The National Health Service* (NHS) might use a register compiled primarily for social security purposes. This would be a simple form of integration within a department.
- (ii) *DES* contemplates holding teachers' salaries and pensions records for on-line interrogating and updating by local authorities using data links.
- (iii) The *Home Office* police records system will hold a central data base of information available on-line to all police authorities throughout the country. This may eventually be linked with computer-based command and control systems developed for particular police authorities.

(b) *Planning:*

- (i) *MOT* will develop joint inter-departmental computer-based projects using models for, eg urban area and transport planning. This will involve *MHLG* and possibly the *Home Office*. The local authorities will need to be brought in.

(ii) The development of the computer-based grid coordinate reference scheme (geo-coding) will involve *MHLG* in planning activities with the *local authorities* and *public utilities*. Geo coding could also link *MHLG* with the *Land Registry* (Lord Chancellor's Departments) and *Ordnance Survey* for planning the use of land and environmental research.

(c) *Functional integration*

(i) *Customs and Excise:* The London airport scheme, devised in conjunction with the airlines, shipping and forwarding agents for the documentation and customs control of freight imports will integrate customs clearance, cargo control and the provision of accounting and statistical information. This is a major example of integration between central government and elements in both the public and private sectors. The system will be provided for all the users by NDPS.

(ii) *Meteorological Office:* The Meteorological Office at Bracknall and the Water Resources Board at Reading have common interests in climatological data. This limited contact could conceivably develop in a different field of activity through the provision of an integrated computer-based system, bringing in Mintech (Water Pollution Research Laboratory; Hydraulics Research Station) and the National Environmental Research Council for research into the problems of water resources and flood control.

(iii) *PGO:* The department tentatively advanced to us the suggestion that it might act as the central bill paying agent for a number of small departments. The PGO recognises the difficulties it would have in persuading departments to participate in a computer-based scheme of this nature but consider that it merits investigation.

(iv) *MPBW:* This department has for some time operated an integrated computer-based system for stock control, estate properties, building contracts, transport and unified accounting and statistics. There may in future be links between the departmental computer systems and those of the construction industry, eg over the design of buildings. Work affecting the construction industry is already carried out on the department's computer at the Building Research Station, Watford.

Seebohm Committee

188 There is one further, potentially large, field for integration within central Government which would also involve the local authorities. It arises from the possible reorganisation of the local authority personal social services following the report of the Seebohm Committee.[3]

189 In brief, the Seebohm Committee recommends the formation within local authorities of a unified social service department which would incorporate the present functions of children's and welfare departments, together with elements from the education, health and housing departments. The Committee endorses the view that a single central government department should

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[3] Report of the Committee on Local Authority and Allied Personal Social Services, July 1968 (Cmnd. 3703). The social services concerned are those for children, old and physically and mentally handicapped people.

be responsible for the relationship between central government and the proposed social service departments. It does not suggest what form this unification of responsibility at central government level should take. It could, for example, be achieved by creating a new central government department or by giving the responsibility to an existing government department. But it does stress that the new organisation which it recommends would depend very much on effective research based upon a regular and reliable supply of basic data. The Committee therefore recommends the creation of a central research and intelligence organisation which should cut across departmental boundaries and cover social services outside local government, eg health and social security. The report goes on:

> 'We see the main task of the new central unit as assessing what information is wanted; providing a common definition of terms; advising local intelligence units and others on the techniques of collecting and disseminating information, and specifying the minimum amounts of local standard information to be collected, collated and compared. It would itself collect and publish information on a national basis in relation to the work of the Census and of other departments. It would sponsor and coordinate research on matters connected with the social services.'

If a new central government department were set up for coordination of work on the social services the Committee would assign to it this research function.

190 Clearly, therefore, if the major recommendations of the Seebohm Committee were adopted in principle then, whatever the precise form of the new organisation, there must be some integration at central Government level, at least for statistical and research purposes, and computer-based systems will be affected. DES, DHSS, Home Office and MHLG must presumably be involved together with the local authorities and, possibly, the voluntary services.

Special studies

191 We have expanded our general review across Government to make a more detailed investigation of a number of the bigger departments with extensive computer applications, and of Government Statistics. These special studies have in fact provided us with our most useful indications of the probable course and speed of systems integration in Government. They certainly brought to light the difficulties which have to be overcome, and pinpointed the basic issues which need to be resolved before integration in this form can or indeed should take place. The information obtained from these special studies therefore lies behind many of the conclusions to this part of the report.

MINISTRY OF DEFENCE

192 We selected this department for special consideration primarily because of the number and variety of its computer applications. MOD is the biggest user of computers in Government and we concluded that in many respects it would serve as a microcosm of computing in Government at large. In particular we wanted to establish whether the formation of a unified MOD some five years ago had provided the opportunity for integration on a significant scale.

We recognised of course, that the three Services continue to exist with separate personnel and structures, each committed to a different range of tasks for which each has evolved its own distinctive methods. This is particularly true at the operational level. This makes it dangerous to press analogies too closely. Nevertheless, with this qualification, we are satisfied that the experience of MOD serves as a general illustration for Government of the problems and possibilities of functional integration.

193 We have considered functional integration within MOD under two broad heads:

(a) Integration within each Service department.

(b) Integration between the Service departments.

Integration within service departments

194 Within each of the Services, there has been extensive integration *within functional areas* such as pay and stores and, generally, the process (which is continuing) has been facilitated by computers. For example, each of the three Services has moved towards internal integration of its stores supply system. This process is most advanced in the RAF where all stores depots are connected to the control centre at Hendon, data being transmitted via the normal teleprinter network and output in the form of encoded papertape. Integration is least advanced in the Navy where victualling and armament stores are still separate from other stores but there are plans to bring these together on computers during 1971/72.

195 Integration between different functions within each Service has begun and is likely to be extended. For example:

(a) *Navy Department:*

  (i) The Ship Department of Director General, Ships, has recently concluded a preliminary study of the data processing requirements of the whole range of activities covering the design and production of ships for the Royal Navy.

  (ii) Within the naval dockyards computers are being used for the inter-related functions of pay, costing, production control, stores, and accounts. Further developments are in hand.

(b) *Army Department:*

  (i) As in the Navy, plans are being made for the closer integration on computers of contracts and accounts.

  (ii) When the new computers for Army pay come into operation in 1970/71 they will provide information to the reorganised Army Records Office.

(c) *Air Force Department:*

  (i) The pay and personnel records of RAF other ranks are already integrated on the computer installation at Innsworth.

  (ii) The system to be provided at Swanton Morley for the technical maintenance of aircraft and aircraft equipment is to be integrated with the related functions of stores, pay and accounts.

Inter-Service integration

196 Integration within each of the Services seems to be developing steadily. Integration between the Services has not yet got so far. There are two developments to report:

(a) *Stores:* The Navy provides 'single Service management' for food, the Army for motor transport and small arms, and the Air Force for accommodation stores and aircraft equipment. This involves some limited use by each Service of other Services' documentation. So far it has not led to any integration of the respective computer systems for each of the three Services' stores, but limited integration is being planned.

(b) *Civilian pay and records:* The Defence Civil Pay Project, which is directed by the Director-General of Defence Accounts, will achieve a considerable measure of integration for the pay of all MOD non-industrial staff and most of the industrials (ie except for example those from the Navy Department who are paid from the dockyard computers (see paragraph 195(a)(ii)). This integrated system will be based upon two computer installations in the ICL 1900 series, at Cheadle Hulme and Bath. Personnel records for non-industrial staff will subsequently be added and the system will tie in closely with PRISM.

197 There are also possibilities of integrating in the area of accounts, where so far there has been negligible progress except possibly at the higher levels. The Defence accounting divisions have now been integrated under the Director-General of Defence Accounts, and it is reasonable to predict that this will lead in due course to integrated computer-based systems both within and between the Services for Vote and estimate purposes, management accounting and functional long-term costings and expenditure control.

198 There are two functional areas which appear to offer scope for extensive inter-Service integration, ie logistics (within which heading we include stores, contracts, maintenance and repair) and pay and personnel. We have examined both areas in some detail to determine the role of computers and to isolate the important factors which militate against integration.

(a) *Logistics:* Apart from the single Service management for certain items to which we have referred in paragraph 196(a) there is at present no intention, at least in the shorter term, to integrate generally in the stores field between the three Services. Any decisions on integration will be taken by the Defence Supply Committee on general policy grounds. The central Management Services (Computers) Division (Man C Division) in MOD will be consulted on the computer aspects. Their prime concern will be to ensure that differences between the computer systems of the respective Services do not preclude or complicate such functional integration as may be found to be desirable. For example, the division has very much in the mind at the present time the advantages of achieving computer compatibility between the computer systems for the maintenance and repair organisations of the three services and the related functions of stores, pay and accounts.

(b) *Service Pay and Personnel:* Each of the three Armed Forces has a different philosophy and organisation for dealing with the pay and personnel records of servicemen. The Navy now has a manual pay system, though an ICL 1904E has recently been delivered to take on sailors' pay. The Army's pay is on computers which are to be replaced during 1970/71 by IBM 360/50 machines, but it has separate Records Offices, currently being reorganised. The Air Force has an integrated pay and personnel system for other ranks based on a Univac 1107 installed in 1965 and due for replacement not later than 1974. The pay and records system of the three Services are therefore fundamentally out of phase in terms of organisation, type of computer and the dates on which the computers will need to be replaced. As with logistics, important operational considerations underlie some of these differences and we have been told that it must be five to ten years before there can be any major rationalisation. The recent review of Service pay by the National Board for Prices and Incomes has, however, promoted some inter-Service coordination on pay matters with which ADP staff are associated.

General position

199 There is considerable integration within each function within each Service and a growing trend towards integration between functions within each Service. Where functional integration is achieved it is closely related to the integration of ADP systems but, in general, the latter follows rather than leads in the process. So far there has been comparatively little integration of function between the Services, and in important areas – eg logistics, pay and personnel – such integration can only be achieved towards the end of the 1970s. It will only take place then if it is approved on operational and general policy grounds.

200 This situation is accepted by Management Services (Computers) Division (Man C Division) in MOD. It regards computers, correctly in our view, as the tool of integration and not as the prime reason for it. It is nonetheless planning for eventual inter-Service integration by creating the conditions in which such integration can readily be achieved. It is helped in this task by the fact that it is organised on a functional basis across all three Services. It realises that, if it is to make an impact and influence events, it must plan effectively and in depth. The need wherever possible to promote compatibility in ADP equipment is fully recognised. There are at present more than 80 computers in use for administrative and scientific purposes in MOD covering 20 different series. Man C Division has plotted the replacement dates of all computers presently in use, and will take the advantages of compatibility fully into account with other relevent factors as each comes up for replacement.

201 Standardisation is recognised in MOD to be an essential precondition to the integration of computer-based systems and Man C Division is working in close collaboration with other groups to promote this. In the important field of stores, an ICL 1904E is being installed at the Defence Coding and Classification Centre, Hullavington, under the Director-General of Supply Coordination, to secure the use of unique and unambiguous identification of each stores item covered by NATO agreements, independent of manufacturer or user. The Director-General of Supply Coordination, through the Standard Language Authority, is also planning for the standardisation of systems, interrogating languages and codes on the supply side of all three Services.

DEPARTMENT OF HEALTH AND SOCIAL SECURITY AND INLAND REVENUE

202 There are two main reasons for reviewing ADP developments in these departments in parallel and in depth:

(a) DHSS is a 'federal' department recently formed from the merging of the Ministry of Social Security with the Ministry of Health. Inland Revenue, though not a federal department in the same sense, consists of several large branches exercising their executive functions with considerable independence under the general authority of the Board of Inland Revenue. In each, therefore, there could be scope for the 'internal' integration of computer based systems serving hitherto separate parts of the respective departments.

(b) The two departments together account for a significant part of the total volume of cash transactions between central Government and the public at large.[4] It is an essential feature of both systems that the taxpayer and the recipient of benefit declare separately details of their personal circumstances (though not necessarily the same particulars for each purpose). Prima facie, therefore, the activities of the two departments afford scope for a major integration of function in order to rationalise and reduce the requirements upon the public to render personal details.

Internal integration

203 The ADP resources of DHSS will be fully extended until the mid 1970s in bringing both the earnings related scheme at Newcastle-upon-Tyne and the regionally based short-term benefit scheme successfully into full operation. The short-term benefit scheme will, incidentally, assume the payment of unemployment benefits which is currently handled by the local offices of DEP. No resources will therefore be available for some years to consider in detail the possibility of a common data base of information to serve the whole of the social security side of the department. The merging of the Ministries of Social Security and Health provides very limited scope for functional integration because of the essentially distinct nature of the work of the two sections.

204 On present plans the Inland Revenue will be fully committed for the decade to 1980 to the scheme for centralising PAYE and, as outlined in Chapter Three, to putting some of the clerical and accounting processes associated with other taxes and with collection work on computers. It is intended to use machines in the ICL 1900 series for these applications and this will foster compatibility. These developments do not amount to integration of the PAYE, Schedule D, corporation tax, etc collection and surtax systems. This would, of course, require legislation. It would involve complete reorganisation of the departmental structure and of its methods of working. It is not, therefore, basically an ADP matter though computers could greatly facilitate any changes which were considered to be desirable on operational grounds.

Inter-departmental integration

205 Up to the present time the two departments have not had sufficient

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[4] Inland Revenue assesses and collects tax from 25 million individuals and 300,000 companies. DHSS makes 16½ million payments weekly (in benefits and allowances including supplementary benefits). The full earnings related scheme will cover 35 million individuals.

specialist manpower available to give consideration to the feasibility and possible advantages of integrating in some way their separate computer-based systems. The bringing together in some way of functions of the departments is not primarily an ADP issue, though some of the technical problems would be difficult to overcome with the equipment likely to be available in the next few years.

General position

206 It is entirely right that the two departments should give top priority to ensuring the success of their big schemes. Their prime responsibility must be to meet Ministerial requirements and to service the public promptly and without risk of breakdown. Nonetheless, it would be desirable for consideration in depth to be given to systems integration, both internal and between the departments.

207 There are obvious advantages in integrating at least some of the systems of the two departments. It could produce some economies in data preparation: these could be substantial. It could reduce the number of contacts with and amount of information required from the public. It would be an essential first step towards a 'Government transactions system' if, in the light of technological developments, this was considered to be a viable and generally desirable innovation. So far, there has not to our knowledge been a thorough-going attempt by an inter-departmental team to determine the volume of data which is likely to be common to the two departments. Uncertainty about the detailed requirements of new legislation makes for difficulty. But until such an assessment has been made, it will not be possible to assess objectively the scope for and problems involved in integration of the systems of the departments. The decision on integration will turn on basic questions of organisation, operational efficiency and general policy. Those taking the decisions should have before them, however, a jointly agreed, detailed assessment of the data processing considerations.

208 Some of the computers of DHSS at Newcastle-upon-Tyne are due to be replaced in the mid-1970s. The first of the Inland Revenue's PAYE computers will be coming up for replacement about the same time. Planning some of the replacements must begin by 1971. Not later than this date therefore, we *recommend* that a joint DHSS-IR team consisting both of the senior ADP staff and senior officers from the policy divisions should be formed to examine in depth the case for functional integration in some form of their respective systems. If this is not done then the opportunity to prepare the ground for any desirable integration may be lost until well into the 1980s.

209 We do not minimise the practical difficulties. Senior staff are limited in number and otherwise heavily engaged. They will at the same time need to consider the possibilities of systems integration within their respective departments. In addition, DHSS may have to review with DEP the structure and function of the local office organisation in the area which the two departments cover. In the case of the Inland Revenue the implications for its systems of proposals for some form of local taxation (depending on the recommendations of the Royal Commission on the Constitution) may also be requiring urgent attention, in conjunction with other departments and organisations. The fact

remains: either the case for integration which has been advanced on several occasions is examined in depth over the next few years or, for all practical purposes, it is indefinitely deferred. Priorities will therefore have to be set.

GOVERNMENT STATISTICS

210 Of all the functional classes of activity carried on within Government that undertaken by the Statistical Service is probably most amenable to integration in terms of ADP. This is because statistical information is particularly suitable for computer input, the systems requirements are usually well defined and the processing of statistics on computers has been developed in many countries for a good number of years. Furthermore, although decentralised to departments, the Statistical Service has an effective means of communication through the Central Statistical Office (CSO).

Earlier reviews

211 In their report the Government Statistical Services published in December, 1966,[5] the Estimates Committee recommended among other things that the CSO, in conjunction with others, should consider the feasibility, costs and benefits of converting the existing structure of collection, analysis and dissemination of official statistics to computers. The Committee was particularly concerned that provision should be made for the continuous input of data to the system and for multiple access to the same prime data by different departments, regional organisations and, within the limits imposed by confidentiality, private enquirers.

212 A further recommendation of the Estimates Committee was for a standing group drawn from both inside and outside the Civil Service to examine existing computer installations and the development of computers and their application to the Statistical Services. An Advisory Committee on Computers was formed. The Committee was informed that Statistical departments were very short of computing capacity. They therefore suggested that the (then) very limited compatibility between installations used for statistical work should be improved so that surplus capacity could be used more extensively. To this end the Committee advised that the new Computer and Data Systems Unit (CDSU) within CSO should assume responsibility for the central planning of computer systems for the whole of Government statistics and for overseeing centrally the execution of these plans.

Subsequent developments

213 The CDSU has been formed within CSO and given the general task of achieving greater integration and compatibility of computer systems used for statistical purposes. Initially it is to concentrate on the computerisation of industrial and business statistics (ie in connection with the setting up of the Business Statistics Office – (BSO)); it will examine in the light of technical developments, such things as the creation of data banks. In addition to CDSU, a small unit in CSO is working on the standardisation of definitions and classifications (eg industries, occupations, commodities, regions) to achieve the

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[5] *op. cit.*

maximum possible uniformity across Government. Standardisation in this way is essential to the satisfactory development of computers in the Statistical Service.

214 We were told by the head of CDSU that, for some time to come, his very limited resources will be fully extended by work in connection with the Business Statistics Office, and, to a more limited extent, on the provision of computer facilities for the CSO itself. The Unit has not so far been able to devote any resources to considering how the compatibility of computers used for statistical purposes might be improved. Nor has it been able to give much attention to the central planning of computer systems for the whole of Government Statistics.

215 There has, however, been an improvement in the general situation over the past three years. Until the mid-1970s, there will remain some pockets of incompatibility between the computers used in different departments for statistical purposes. But the increasing concentration of Government on the ICL 1900 series machines, and the drawing together of both business and social statistics, to which we refer later, will minimise the practical consequences of this remaining incompatibility. Furthermore, we did not obtain any evidence to suggest that statisticians in departments are now short of computing capacity, and the head of CDSU confirmed that, generally, the position appeared to be satisfactory. The Scottish Office Computer Service in Edinburgh and the Central Computer Bureau recently relocated in an expanded form in Norwich will both provide computing facilities for departments' statistical work. There is some doubt whether the ICL 1904 to be used for the 1971 population census will be adequate as it stands for the task, but replacement of the central processing unit and enhancement of the core store will probably be authorised.

General prospects

216 As Professor Moser has pointed out,[6] a fully integrated statistical system making really effective use of computers probably demands complete centralisation of the Statistical Service. The great advantage of a decentralised system of the British pattern, in which individual departments have their own Statistics Divisions, is that statisticians can participate directly in formulating policy. It is therefore proposed on these general grounds to continue with the existing arrangements in their essentials, and this must retard progress towards the development of fully integrated computer systems servicing Government Statistics at large. There will, however, be gradual and limited progress in this direction under the coordinating influence of CSO, particularly when CDSU can allocate resources to its wider tasks. Technological developments and the increasing standardisation of definitions and classifications in all departmental Statistics Divisions should, at the very least, make it possible to collect and store data centrally, leaving the work of analysis and interpretation to individual departments.

217 It is important to note that in statistics, as in other parts of Government, the decisions on integration have been taken on general policy grounds and not with prime regard to data processing considerations, though the form

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[6] See Statistical News, Vol. 1, pp. 1. 1–1. 6, published by HMSO on behalf of CSO.

these take is directly affected by the decision. This underlines the fact that, while computers can facilitate integration, they do not in themselves provide adequate grounds for it.

218 Though integration of Government Statistics at large is likely to proceed slowly, two major developments involving important categories of statistics will dominate the statistical scene during the 1970s and should bring about an extensive measure of integration within their respective areas. These are the development of the BSO at Newport, Monmouthshire out of the Board of Trade Census Office, and the proposed formation of an Office or Bureau of Population and Censuses from the General Registry Offices for England and Wales and Scotland and the Government Social Survey, covering social and including household statistics.

Business Statistics Office

219 The functions of this office will be to compile and maintain a Central Register of businesses and to bring into existence a new system of industrial statistics, superseding the present quinquennial census of production supplemented by short-term enquiries including those at present made by other departments. The programme of statistics for the distributive and service trades is also being reviewed. The Office will take over from departments the responsibility for collecting the whole range of business statistics, including eventually the annual census of employment. The methods by which BSO will serve other Departments such as MAFF, DEP, Ministry of Power, MPBW, Mintech and other parts of the Board of Trade remain to be worked out, but the principle of inter-departmental collaboration is well established.

220 One of the longer term objects when the Central Register has been compiled is to build up a data-bank or banks from which detailed information, some derived from surveys, can be made available, promptly, to industry.

221 The formulation of overall policy and the work programme of BSO is the responsibility of a management committee under the chairmanship of the Director of the CSO. The BOT (including the BSO), DEP and Mintech are represented on the Committee. Subject to the direction of the management committee on policy, the Director of the BSO is responsible to the Director of Statistics, Board of Trade, for the day-to-day operation of the Office. The management committee has appointed a Systems Coordinating Committee consisting of representatives of the BSO, Board of Trade, Mintech and CSD and chaired by a representative of the CDSU. The job of the Systems Coordinating Committee is to coordinate systems development in the Office and to advise the Office and the management committee on computer facilities.

222 The drawing together of industrial statistics in the way proposed under the policy guidance of the management committee, and with CDSU responsible for longer term planning, will be integration on the large scale.

Social statistics

223 Broadly comparable developments in the field of social statistics[7] are

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[7] These include statistics on population characteristics, housing, education, work, social categories and mobility, income and property, expenditure, social security and welfare, health, law and order.

taking place more slowly. They depend initially on the decisions to be taken on a number of major topics including the formation of the proposed Office of Population Censuses and Surveys.

224 The most probable course of events is the merging of GRO and the Government Social Survey in an Office of Censuses and Surveys which will, as regards the Census, coordinate developments on the lines recommended by the Estimates Committee and will expand the current activities of the Social Survey to include the bulk of survey work for all policy making departments. It will, for example, presumably take over from DEP responsibility for the Family Expenditure Survey and undertake any multi-purpose household surveys.

225 The Office of Censuses and Surveys would, we understand, be guided by an advisory committee under the chairmanship of the Director of the CSO who would thus be able to coordinate its activities with those of BSO and the Statistical Service generally.

226 We understand that the GRO does not promote standardisation in the field of social statistics. Several departments are apparently working independently on systems and computer programs for the handling of social surveys. Some of the work has general features and we recommend that CDSU, strengthened as necessary, should assume the responsibility for coordinating it.

Integration of business and social statistics

227 Although the Director of CSO will be associated with both the BSO and the development of social statistics a close linkage is not proposed between the two. There will, however, be some connection between business and social statistics through manpower and employment statistics and these contacts might develop. We understand that the decision to set up separate organisations was influenced by experience in the USA where the Bureau of Censuses undertakes both functions. Little scope has apparently been found in the United States for the linkage of data, and complete centralisation has led to practical difficulties at working level.

228 Although in comparison with other functional areas of Government statistics is a relatively straightforward subject for integration, progress in this direction still seems likely to be gradual. In the fields of business and social statistics where the advantages of integration are widely accepted, the pace will be dictated by the complexity of the tasks and the limited resources of skilled staff available to undertake them. Over the remaining area of work covered by the Statistical Service integration will be constrained by the largely decentralised form of the Service and the departmental nature of much of the work. Once again, the determining factors are those of general organisation and policy and not ADP considerations. But the need for general coordination, standardisation and compatibility of equipment is realised. The trend is towards the integrated use of computer systems and when integration is wanted it is not likely to be seriously impeded by ADP considerations.

229 CSO, with its central responsibility for overall planning of the Statistical Service, and CDSU in particular, should play a leading role in the development of integrated computer-based systems for statistical purposes. But the unit

must be strengthened if it is satisfactorily to discharge its task. It will of course need to work closely with MS(C) Division, CSD, more particularly because departmental computers are not on the whole used exclusively for statistical purposes.

230 Because complete centralisation of Government statistics under the CSO has been ruled out the Office will have some difficulty in exercising its coordinating and directing functions. Arrangements broadly on the lines adopted or likely to be adopted for managing and advising the BSO and the Office of Censuses and Survey may therefore become necessary as the need for integration through computers emerges in other areas of statistics. We presume that the operation of these management committees will be monitored carefully so that any modifications which experience shows to be necessary may be incorporated in any subsequent arrangements of this kind.

Management information systems (MIS)

231 The Diebold Research Programme has defined a management information system in the following terms:

> 'It is an information system making use of available resources to provide managers at all levels and in all functions with the information from all relevant sources necessary to enable them to make timely and effective decisions for planning, directing and controlling the activities for which they are responsible.'

232 It is obvious from this definition that management systems for the control of cash, plant, materials and labour, and providing a framework for decision taking and policy making, have always existed in some form and owe nothing to computers. But the difficulties of providing the right sort of information at the right time have increased with the growth in the size and complexity of organisations and the tendency to decentralisation. The present world-wide interest in the formal development of computer based management information systems stems largely from the growing need of management at all levels for accurate, comprehensive information for the effective control of work, and the formulation of policy, allied to the capacity of the computer to collect, store, process and distribute data with great speed. The computer makes it possible to assemble and process information quickly from a number of decentralised units, eg branches of departments or even departments themselves. It can present the results in print or visually on the screen of a display unit direct to the manager. Thus, though the computer is not an intrinsic or fundamental part of the information system, the extensive, integrated system cannot in practice function without it.

233 We are not concerned in this section of our report with information retrieval as a general subject. We have referred to this already in Chapter Three.

234 Although a vast amount has been and is being written about the 'integrated management information system' we have formed the impression that, in the main, these publications skate superficially across the surface of a

complex subject. Certainly they do not provide much of a guide on how to get to grips with the practicalities in the context of central Government. We have therefore based our conclusions on the results of our review of developments in the commercial field, in the public sector outside central Government, in Government abroad and, finally, within Government in the United Kingdom.

EXPERIENCE OUTSIDE CENTRAL GOVERNMENT

Commercial and industrial concerns

235 We made a detailed examination of developments in two companies representative of the most advanced in this field. We chose one of them because it now has in operation an extensive information system containing all the marketing and commercial information needed by the company, and providing an enquiry service for management; and the other because it is an extensive group with a central computer unit servicing all the subsidiaries.

(a) *Company 'A'*

(i) This company stressed to us that the successful development of its information system was attributable primarily to the fact that it was a uni-functional marketing organisation, comparatively simple in structure and with single and definable objectives. Furthermore, the basic files relate directly to the sales and accounting operations; the information is in effect extracted as required from the operational data processing system. The company accepts that, at this stage, its MIS is of a comparatively simple kind. It is frankly sceptical of the possibility of designing a fully integrated MIS for a fragmented organisation with different sectional objectives, different demands upon the system and without common standards. We were told, for example, that a related company with several distinct functional groups is having serious difficulty in setting up its centralised MIS.

(ii) The data base for this company's system, including the control and retrieval programs, took seven top quality highly paid specialists twelve months to develop. On particular techniques they worked with three other specialist teams. Management was responsible for defining the information it was likely to require in discussion with the ADP specialists. 150 analysts and programmers are now working on applications programs.

(b) *Company 'B'*

(i) This company regards as impractical massive data banks of information providing an integrated MIS for all the subsidiary companies in the group. It considers that information systems will work when designed for a specific and limited purpose. Computers feature in the design of the system only as an efficient means of providing information quickly and accurately.

(ii) A financial management system is being designed for one division of the company. The first stage was to determine general policy. This took a year, with the senior directors of all companies in the division, and the head of the central ADP unit, attending regular fortnightly meetings. A further year was spent at senior management level in developing these basic policy documents and standardising on procedures and codes. Again ADP staff participated. High quality ADP staff (the systems designers are all graduates) are now working full time on systems and programs. The job is expected to take four years.

Nationalised industries

236 One of these industries is building up a data bank of pay and personnel information in the expectation that enquiries will be made direct from its staff departments using terminals.

237 The same industry has also been working on an information system for business planning. A system for short-term budgetary control has been successfully designed but the team has run into difficulty over the medium and long term systems. Although senior management has defined the long term objectives it has proved impossible to translate these into detailed and meaningful procedures. Management are now considering a more limited approach, while recognising that by doing so they run the risk of producing incompatible subsystems.

Local authorities

238 We understand that NDPS is currently developing the nucleus of an information system for two local authorities. The nucleus is being formed by examining *all* the functions of the local authorities in conjunction with senior officials (eg borough treasurers) with the object of building up key files of persons and property. The senior officials of the authorities are required to indicate their immediate requirements and to anticipate future needs as far as is possible. NDPS will then aim to design the files in flexible form so that they can be expanded to meet future requirements as these emerge.

239 The National Computing Centre (NCC) has been working with local authorities in Wales on a project which will include the development of an information network covering health, education and planning.

240 Both projects appear to be in their early stages. To the best of our knowledge there is no formal communication between NDPS and NCC about them. Nor does there appear to have been any sustained contact in depth with central Government departments although there are obvious interests in common.

EXPERIENCE IN CENTRAL GOVERNMENT

Overseas

241 In the time available to us we have not been able to conduct any first hand research into developments abroad. We have therefore had to rely on other sources for our information. It is obvious from these reports, and from other information which we have obtained, that considerable effort is being directed to the development of properly coordinated management information systems by both the US and the Canadian Federal Governments. It is much less easy to determine precisely how far the process has gone in each case, what success has been achieved and when the fully integrated systems will be completed. We have, however, been told by MOD that the US Marine Corps

has a system of this sophistication successfully in operation.

242 In the field of financial management, the US Government is concentrating on the development of the Planning, Programming, Budgeting System (PPBS) in both the Defence department and civilian agencies. Since 1965, PPBS has been introduced in 26 civilian Federal agencies in the USA. Between 1966 and 1968 some 900 additional staff were required for this work including professionals and ADP specialists. Over 1968/69 another 150 staff have been added. We do not know how many of these are ADP personnel. We are told that, after five years, some agencies are still experiencing difficulty in applying the system. It is dangerous, of course, to draw comparisons without first analysing in some detail the differences between the US and the UK systems of Government finance. Nonetheless, the US Government had the advantage that it started to develop PPBS on the foundation of a management accounting system. The UK Government does not have this advantage. Staff costs of developing PPBS in this country are certain to be heavy and progress is likely to be slow.

243 The Canadian Government has integrated its armed forces to form a unified Service and the Department of National Defence is embarked on the attempt to create inter-linked computer based information systems. The object is to provide filtered data required by the senior policy makers. The overall strategy has apparently been settled by the senior policy makers. Now, in accordance with these broad directives, individual blocks or self-contained sub-systems providing information at lower levels have to be developed. The need for standardisation of data coding across all the sub-systems in the hierarchy is recognised and a central unit therefore maintains a register of codes which have been approved for general use. More than 200 Service and civilian personnel are engaged on the project, including more than 50 systems and programming staff. The project is said to be moving ahead slowly and will take at least seven to eight years to complete.

United Kingdom

244 In their simplest form, management information systems draw off basic data from the computers which are provided for operational purposes. Computer based MIS in this somewhat rudimentary form already exist in a number of Government departments. Thus, in MOD, there is a feed-back of information for management purposes from the computers installed in ordnance factories and dockyards, and from those used in connection with the Army's maintenance and repair unit at Woolwich. There is a similar system in MPBW where there has been some integration of ADP systems concerned with stock control, estate properties, building contracts, transport, accounts and statistics. But, generally speaking, we found from our discussions with departments that very little attention has been given at the design stage of most of the computer systems at present in use for operational purposes to the possibility of obtaining from them information of a kind and quality beyond the capacity of a manual system.

245 There are now moves in hand to develop within central Government advanced and, in some cases, integrated management information systems. Although some of these will be extensive they still fall short of the concept of one single totally integrated system serving all the management processes of

Government. The developments are:

(a) *MOD*

(i) Prime responsibility for development of MIS in this department rests with the Management Techniques and Information Systems Division (ManTIS) which works closely with Management Services (Computers) Division. The ultimate aim is to provide, at the end of some 10–15 years, an integrated financial management, statistics and information system for the whole department. As a first stage, a Navy department team has been expanded to include representatives of the other Service departments to develop for the whole of MOD by 1972 a standard management accounting code and a standard system for the storage of financial information in Vote and functional form. The system will thus cover all Defence Votes and functional costings. We understand that this initial study will require between 25–30 staff from HEO to Assistant Secretary.

(ii) A ship upkeep information system (SUIS) is being designed by the Navy department for gathering and processing information concerned with the many aspects of ship upkeep. The computer should come into operation in 1972. This is intended ultimately to be an integral part of a much larger information system for the Navy which will take at least 10 years to develop, and then only if sufficient staff can be provided for the project.

(b) *Mintech:* This department is operating an information system covering nine research stations. The databank includes abstracts describing the essentials of the research programmes and the effort involved in these quantified in terms of personnel and money. The system is based on an ICL 1907 at RAE Farnborough. Multi-access facilities with a terminal in London are planned.

(c) *MOT:* A joint project team including CSD membership is to make a study in depth of the feasibility of designing a computer based management information system for this department.

(d) *Financial management system*

(i) For some time the Treasury has been considering, in the context of economic forecasting, how best to provide the basic information which is required to make the management of public expenditure part of the management of the economy as a whole. Simultaneously, consideration has been given in a number of departments – eg MOD, Home Office, DES – to the development within these departments of output budgeting systems.

(ii) In our opinion the need now is to bring these several strands together and to consider in some detail the possibility of designing a comprehensive financial information system to meet the needs of the Treasury and departments.

(iii) On the evidence we have collected we would judge that it will take something over ten years to develop fully a system of this scale and complexity, depending on the staff resources which can be assigned to the work. Until the feasibility of the project has been determined a start cannot be made. Furthermore, the longer the delay in giving a firm lead centrally and laying down general principles the more opportunity there will be for departments to develop their internal systems independently. Full-scale integration could then be extremely difficult. For this reason the Canadian Government, which has already embarked on a project of this kind, decided that it must at the outset prescribe in detail the working rules to which departments must conform in developing their internal sub-systems. In the ADP field this will ensure that level of standardisation without which information cannot be exchanged freely between the constituent elements in the system.

(e) *Pay and personnel*

(i) Proposals have been made for integrating across the Civil Service, through a network of computers, the calculation and payment of salaries and wages with the maintenance of personnel records and a register of posts. The system is intended to provide all the personnel information including statistics which is required for the efficient central management of the Civil Service and by establishments divisions within departments. This Personnel Record and Information System for Management (PRISM) is the only scheme so far worked out in any detail for integrating on a service-wide basis particular functions. It has however, been presaged on a limited scale by the development by the Scottish Office Computer Service in Edinburgh of a common payroll system for the four Scottish departments.

(ii) Initially, use will be made of existing computers and departmental pay and records systems and there will be a gradual progression to a substantially centralised system. The scheme requires a large measure of standardisation and it will have to be planned and coordinated by a central unit in CSD. It is proposed that this unit should be generally responsible for setting and introducing standards, and for systems design and programming work for the whole of the personnel system. It may also operate the central computer installation.

(iii) The initial feasibility study for PRISM took about a year to complete and required nine officers of SEO rank and above and an external senior management consultant. If the scheme is approved it will take about 10 years to implement fully, provided the necessary staff are made available. More than 150 people will be required for the central unit in the latter part of the project, about 60 of them EOs and above. In addition there is estimated to be about one thousand man years of work in departments. Some departments with heavy ADP commitments have told us that they will not be able to divert resources to the integrated pay and personnel project until the mid-1970s.

(iv) The development of management accounting and computer-based output budget systems *within departments* may in some respects be complicated by the formation of an integrated pay and personnel system in which information on these matters is held and processed *centrally* on behalf of departments. The difficulties can no doubt be resolved, but we strongly recommend that this matter should be reviewed promptly. One snag is that until a central financial management project team is formed the PRISM unit can consult only with particular departments.

(f) *Statistics*

(i) In a general sense statistics make a widespread and substantial contribution to the provision of management information in Government. This is presumably why, in some other countries, Government statistics are regarded as a strong framework on which integrated information systems can be developed. In this country the development in due course of a data bank at the BSO which can be accessed by several departments and the public, and the setting-up of a macro-economic data bank within CSO, will provide integrated, computer based systems of the kind we have reviewed in this section of the report. This macro-economic data bank will be designed as the central storage point for the main statistical data held by CSO. It is intended that the information should be available to the public as well as to Members of Parliament and Government departments. But this again must be a gradual and probably lengthy development and will very much depend on the number and quality of staff available to design systems of the complexity envisaged.

246 More remote developments conceivable in the longer term include:

(a) *Home Office:* The merging of national criminal statistics and crime statistics could lead, by about 1980, to the development through the police records system of an integrated law enforcement system. This would involve links with MOT Swansea, the courts, probation service and prisons. There could conceivably be international connections.

(b) *Lord Chancellor's Departments:* If the Royal Commission on Assizes and Quarter Sessions recommends a unified court system, including the county courts and the magistrates' courts, this could lead in turn to the development of a national justice information system linked with the law enforcement system.

GENERAL POSITION

247 The development of extensive integrated management information systems to serve multi-functional organisations on the scale of Government is, generally, at an early stage. If the systems prove to be feasible, it is going to take 10 years or more to bring the more complex of them into full operation. On present evidence we think it unlikely that these will eventually form a single all-embracing information system for Government.

248 In our view the most positive way of making progress will be to start by developing information systems on a small scale, at the same time providing for the gradual build up of an integrated system eg by the filtering of selected items of information into a central computer system. Basically, this is the philosophy of the Civil Service Personnel Record and Information System. One advantage of this 'decoupled approach' is that it makes it easier to accommodate subsequent changes in function or organisation. It does, however, require central coordination and direction both in framing overall strategy and in ensuring the necessary degree of compatibility between particular systems.

249 A start could be made on these lines when departments redesign their

administrative data processing systems on replacement of existing equipment by more powerful installations. Wherever possible we recommend that opportunity should be taken to incorporate in the new systems data bases derived from the operational processes. The data bases can then be used directly for more effective management of the operational processes and may assist at a higher level in the formulation of policy. It is particularly important that statisticians in departments should be directly involved in this redesign of systems so that administrative procedures can be developed with statistical by-products in mind.

250 The development of information systems will demand comparatively large numbers of specialist staff and the close involvement of senior officials. In some cases it will require cooperation between central Government and external organisations such as the local authorities and nationalised industries. The work of planning and designing the systems will be appropriate to multi-discipline teams, including OR specialists, in which ADP staff will participate but, initially at any rate, should not predominate. The ADP specialists will play a vital role in designing the files in consultation with the users in order to anticipate as far as possible future requirements. Technically, the only constraints seem to lie in the area of systems design and organisation of the computer files, and in the capacity of manufacturers to provide operating software. In terms of hardware, computers of sufficient size, and effective data links between systems should be available to service whatever information systems are in operation by 1980.

251 If sufficient staff are not available to implement all the information systems which are found to be feasible in the 1970s it will be necessary to determine priorities. This will be a difficult task for, to our knowledge, no success has so far been achieved in quantifying the advantages which the computer based system is claimed to have over the less formalised arrangements previously in use. The integrated MIS is assumed almost automatically to be worth its cost. We do not minimise the difficulties of trying to put a value on better information. We suggest that further attention should be given to the problem.

Prospects for integration

Scope

252 On the evidence we have obtained we conclude that the integration of separate ADP systems within Government is at an early stage and is likely to develop slowly. The most encouraging trends are the transfer of computer-produced data between departments and with external organisations, though this is a simple form of integration. The integration of computer systems will be much more difficult to achieve and, as the examples of MOD and DHSS prove, will not be fostered by the merging of separate departments into larger organisations where the functions of the constituent parts are distinct and separate. There are, however, developments even in this area of integration. They have proceeded furthest within each of the separate Service departments of MOD and, as experience there and in MPBW shows, may expand most rapidly in the area of stores and contracts. Elsewhere integration in its early

stages will probably proceed through collaboration on particular projects – eg in inter-departmental planning.

253 Even in those areas such as statistics where integration is widely accepted to be desirable, progress will be limited by the complexity of the task and the limited resources available to undertake them. The complete commitment of available resources to the successful introduction of essentially separate systems could, unless action is taken shortly, defer serious consideration of both internal and inter-departmental integration until well into the 1970s. DHSS and IR are important cases in point.

254 We conclude from our review that, as a general rule, the integration of ADP systems must follow decisions in principle to integrate particular functions. The computer cannot lead and it does not provide an effective means for promoting integration where there are strong organisational and policy reasons for maintaining separate operational units. On the other hand, where functional integration is considered to be advantageous, computers can help in the process. They provide additional arguments for integration – eg on grounds of operational efficiency and the economies of scale derived from the maximum use of comparatively high cost equipment.

255 It follows from this that, since there is not likely to be one comprehensive plan for the integration of separate departmental functions, we see no scope for the integration of longer term ADP developments in one comprehensive plan. The re-organisation of departments seems primarily to be a political issue and it is therefore impossible for those responsible for ADP development to predict, even in consultation with those for the time being responsible for policy, what form these future developments may take.

Role of ADP

256 This is not to commit ADP and its practitioners to a passive role. It is essential that, when a decision is taken on organisational grounds to integrate functions, there should be no basic technical obstacles to hamper this. ADP units both in departments and at the centre must therefore work actively to promote standardisation – the condition precedent to integration – in all those areas where computer-produced data can be transferred and where, in the longer term, functional integration appears to be a possibility. They must, in these same areas, have careful regard to the need for compatibility whenever new equipment is acquired or existing computer systems replaced. Computers will in these ways help to create a framework for integration. The process will be further encouraged by the sharing of data transmission facilities and the provision of bureau facilities offering common application programs for use by a number of departments.

257 Removing the technical obstacles is, however, only a first step towards the integration of systems and associated procedures. As part of their longer term planning function ADP units should consider in depth and in the light of technological developments how computers might be deployed more effectively in departments if functions could be integrated or links forged with other departments and external organisations. They should then feed their ideas to senior policy makers in good time for them to be taken fully into account in the decision-taking processes. It is much easier to devise new procedures

from the outset to exploit computers to the full than it is to adapt existing procedures which have been developed without full regard to the potential of ADP. This vital function will demand high calibre staff designated specifically for the planning task. It is incumbent upon departments, including CSD, to make provision for the planning units now, and also to ensure that systems designers and programmers of the appropriate calibre and in the number required are available at the right time to implement plans of the scale and complexity to be expected.

Function of CSD

258 The role of ADP in promoting integration is exemplified by the function we conceive for MS(C) Division, CSD. It must itself assume responsibility for the development of standards for data interchange. It must coordinate the development of standards in those areas where other departments or units bear the prime responsibility. In addition to coordinating developments, it must initiate action in areas in which, from its central position, it can detect latent possibilities of integration. This will involve close contact between the Computer Division and the Machinery of Government and other Divisions in CSD, so that the ADP planners are kept abreast of possible departmental groupings and MG Divisions are aware of developments in data processing. There must also be regular consultation, in association with other departments, with the local authority organisations. This contact with the local authorities will be particularly important when the recommendations of the Royal Commission on Local Government are being examined.

259 It will be a further vital function of MS(C) Division to promote interdepartmental studies by ADP units working closely with senior officials in the policy divisions in the areas where the scope for functional integration appears to warrant examination in depth. In some functional areas – eg Defence – where a central coordinating body already exists, the responsibility of MS(C) Division should be limited to the coordination of developments within these areas with those in Government generally. Where there is no such central link MS(C)'s responsibility should be to stimulate joint action at the proper time, and in some cases to participate in the study. If it is to do this effectively its own groundwork must be undertaken in depth and be of top quality.

260 As we have indicated, the proper time for considering integration is either when new computer systems are being designed or, as will more frequently be the position, when existing systems come up for replacement. The time (known as the lead-time) between initial consideration of a new computer project, or a replacement system, and acceptance of a delivered computer is about 4 years. Planning must therefore begin early enough to allow for this lead-time.

5 Quantitative assessment of future computer requirements

261 A forecast of the overall computer requirements of Government in ten years' time should include an indication of the equipment needed to satisfy this requirement and, as far as practicable, of the cost of this equipment, the buildings to house it and the staff to use it. In this Chapter we attempt to convert the requirements discussed in previous Chapters into overall quantitative terms. We assess the computers themselves in terms both of relative capability, or 'power' as it is commonly described, and representative configurations.

General considerations

262 In estimating scientific requirements we have made use of assessments already carried out in both MOD and Mintech. Both departments have issued questionnaires to particular scientific establishments and the information obtained in this way has been adjusted to take account of the expected growth in scientific computing generally in the United Kingdom. We have also followed MOD and Mintech in assuming, for purposes of quantification, that Government computers will be operated for about 100 hours per week.

263 In making our quantitative assessment we have relied as far as possible on the estimates of computer-operating departments. Generally speaking these cover only the shorter term and well defined plans for replacements and new applications. For the longer term possibilities, including replacements, we have had to form our own views on both the type of equipment that will be required and when it will be wanted. Our forecasts can, therefore, serve only as broad indications and their precision diminishes the further ahead we look. We have, for example, had to decide arbitrarily whether two or more very large computers will be replaced by an equal number of machines or by one still larger machine. Unless there are strong indications to the contrary we have assumed the latter, and we distinguish separately in our estimates those very large machines which come into the upper part of the range.

264 In practice computing requirements are not met by providing equipment of precisely the power needed for the job in hand. Extra power is provided to cover contingencies and provide a margin for any subsequent increase in the work load. The unavoidable overlap while work is transferred from equipment being retired to its replacement also results in surplus power. Our forecasts reflect this unavoidable over-provision.

Quantification in terms of computer power

265 We needed a standard measure of computer power which could be applied to a wide range of machines, past, present and future, and which could be used for both administrative and scientific purposes, in order to produce an aggregate of the total computer power available in Government now and required over the next decade. Without a measure of this kind we could not calculate the past and predicted growth rate in computer power.

266 This is not a new problem. Various attempts have been made, with only limited success, to produce a satisfactory measure of power. One difficulty is that a power rating cannot be assigned with any degree of precision until the task for which the computer is required has itself been defined in some detail. Another is that power for carrying out one task may be inadequate for undertaking another which is similar in some respects. The second task may, for example, require different peripherals and this affects the measurement. It is generally agreed that there is no single measure of power satisfactory for all purposes.

267 In deciding on an appropriate measurement we first considered the various measures of computer power which have been devised for other purposes; viz:

(a) The inverse add-time – ie the number of additions which a given computer can carry out in a second.

(b) An instruction mix – ie a weighted average instruction time based on the frequency of instructions used to carry out a particular type of work. The MOD Scientific Computer Working Party used one of these mixes – the Gibson mix.

(c) The GPO work unit – ie a refined mix based upon GPO-type work.

(d) Benchmarks – ie standard problems for particular types of work.

(e) Measurement in terms of an equivalent machine – eg Atlas; IBM 7090[1]; KDF 9.

268 These various measures presented us with a wide choice, no one of which was wholly suitable for our purposes. Briefly, none took effective account of the efficiency of the software provided with the computer, of multi-programming or multi-processing, or of the operational requirements of a real work load. Furthermore, we needed a measure which would enable us to reconcile the different measures used by MOD and Mintech in forecasting their scientific computing requirements so that we could take account of their predictions in our overall forecast. We therefore decided that, at some risk of causing confusion, we would have to devise another approximate indication of power better suited to our particular requirements.

269 We derived our measure from a grouping based on the ICL 1900 series of computers which currently account for one third of the total number of computers installed, and on order, for administrative purposes, and for two

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[1] This measurement was adopted by the Joint Working Group on Computers for Research (Report, January 1966, Cmnd 2883).

thirds of the data processing capacity expressed in aggregate ADP Mix terms. Using an arbitrary scale of equivalence we allocated a value of eight to the ICL 1904E/1905E computers. Then, we compressed the wide range of processing powers offered by existing and projected computers into a much smaller range of values. At the upper end we allocated to the ICL 1908A (and equivalents) a value of 140; and, towards the lower end, to the 1902A (and equivalents) a value of two. We term these values 'ascribed values' for reference purposes (see Appendix 3 for a list of computer models grouped by their respective ascribed values). This method gives only a low level of precision, for purposes of aggregation. It cannot, for example, be used for the evaluation and selection of equipment for particular tasks.

270 We found that, when we used the ascribed values to assess the power provisions for scientific purposes forecast by MOD and Mintech the aggregated ascribed values corresponded closely to the figures produced by each of these two departments using their own different unit of measurement.

271 Table 5.1 shows the annual and cumulative net growth of computer power in Government over the six years 1 April 1964–31 March 1970 expressed in terms of ascribed values. The cumulative figures for 1964/65 (Col. A, rows 1b, 2b, 3b) include all years previous to 1964/65. Values up to 1968/69 (Cols A–E) are actual: the value for 1969/70 is a good estimate. The figures have been rounded off to the nearest ten units.

Table 5.1

Actual growth of computer power in Government departments 1964/65–1969/70

		A	B	C	D	E	F
		1964/5	1965/6	1966/7	1967/8	1968/9	1969/70
1 Administrative	– (a) Annual ..	10	20	20	80	50	190
	– (b) Cumulative ..	30	50	70	150	200	390
2 Scientific	– (a) Annual ..	20	30	50	30	70	60
	– (b) Cumulative ..	20	50	100	130	200	260
3 Total	– (a) Annual ..	30	50	70	100	120	250
	– (b) Cumulative ..	50	100	170	270	390	650

272 The annual growth rate reflected by Table 5.1, averaged over the past five years and expressed as a percentage[2], has been approximately 50 per cent across computing in Government as a whole. In total the fluctuations from year to year have been relatively small. Within this total rate of growth administrative computer power has increased fairly steadily at 65 per cent per annum. The growth of scientific computer power has been rather more erratic

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[2] $$\frac{\text{Value at 31 March (end of year) minus Value at 31 March (beginning of year)}}{\text{Value at 31 March (beginning of year)}} \times 100$$

and, in the last five years, at a slower average rate of about 40 per cent per annum.

273 Table 5.2 indicates the annual and cumulative growth of computer power which we forecast for the ten years 1970/71–1979/80, again expressed in terms of ascribed value. The cumulative figures are net after deducting the power of computers which will be replaced during the decade. We include administrative and scientific computer power within the one figure because it becomes increasingly difficult to separate them in some areas of application where plans are not clearly defined. The cumulative figure for 1970/71 (Col. A, row 4) includes the 1969/70 cumulative value from Table 5.1. The figures have been rounded to the nearest 50 units.

Table 5.2

Forecast growth of computer power in Government departments 1970/71–1979/80

	A	B	C	D	E	F	G	H	I	J
	70/1	71/2	72/3	73/4	74/5	75/6	76/7	77/8	78/9	79/80
1 Plans clearly Defined – Annual	250	750	750	400	100	200	550	350	700	600
2 Plans not clearly Defined – Annual . .	—	—	—	150	200	400	500	600	1,050	1,500
3 Annual Total	250	750	750	550	250	600	1,100	950	1,700	2,100
4 Cumulative Total . .	900	1,650	2,400	2,950	3,200	3,800	4,900	5,850	7,550	9,650

274 Table 5.2 indicates that the present growth trends may be expected to continue at around 50 per cent per annum until about 1974; and in ten years we forecast that the installed power will have increased approximately fifteen-fold. This increase over ten years corresponds to a mean annual net growth rate of approximately 30 per cent. It is not unreasonable to expect that the rate of growth will drop after the middle half of the decade from the 50 per cent in the earlier years, which is based on current growth and clearly defined plans. If maintained, an annual rate of 50 per cent would produce approximately a sixty-fold increase in computer power by 1980. This is greater than the rate of growth experienced and forecast outside Government in this country and in other countries. Our estimate is, of course, subject to considerable forecast error. The uncertain nature of the forecast is underlined by the fact that in 1974 the plans not clearly defined account for only some 5 per cent of the total forecast: by 1980 the corresponding proportion is about 40 per cent.

275 To sum up, the increase in power over ten years could be somewhere between ten and over twenty-fold.

Quantification in terms of number and size of computer

276 In addition to assessing future requirements in terms of an abstract measure of power we thought it would be helpful, particularly to the general reader, to give some broad indication of what this projection could mean in terms of the number of computers which departments seem likely to require in future, and their relative size. The difficulty in doing this, as in measuring power, is that we have to speculate without knowing in detail what applications the equipment will have to undertake.

277 We defined four classes of computer in terms of the capital cost of the system, at current prices, taking account both of core store size and peripherals, viz:

	£
Small	10,000– 99,000
Medium	100,000–499,000
Large	500,000–999,000
Very large	1 million and over

278 From an examination of a number of systems in each range we consider that, in terms of actual equipment, the following configurations are broadly representative of each class:

Small:	CPU with core store not greater than 16,384 (16k) words and with up to six peripheral devices.
Medium:	CPU with core store not greater than 49,152 (48k) words and with up to sixteen peripheral devices.
Large:	CPU with core store not greater than 131,072 (128k) words and with up to 25 peripheral devices.
Very large:	CPU with core store between 262,144 (256k) and 1 million words with 25 or more peripheral devices.

Unavoidably, this classification is somewhat arbitrary, and some of the machines which we classify as very large will probably be regarded as only large in ten years' time. Furthermore, there are differences between ADP and scientific computer configurations: the latter tend to have fewer peripherals. We do not consider that, for the purposes of our report, these differences require us to provide a separate classification for scientific computers.

279 We are not alone in classifying on these lines in terms of cost. The Netherlands Government has done so in making its forward look to 1985.[3] Its groups are not identical to our own. It works on monthly rental prices. If they are converted to capital value, machines costing less than £168,000 are classed as small, £168,000–£359,000 as medium and those costing £360,000 and over as large. The Japanese Electronic Industry Development Association in its annual report for 1969[4] adopts groupings with cost categories approximating to our own. It does not provide a category for very large machines but it does have a category for an ultra-small category, which we have excluded

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[3] Policy on Automation in Government Departments – Centralisation or Decentralisation of Computers – report of the Commission on Automation in Government Departments, The Hague, May 1968.

[4] Computers in Japan, 1969.

from our review. We understand that broadly similar groupings have been used by OECD and the US Government.

280 In Table 5.3 we forecast in terms of the classes of computer we have defined the possible requirements of Government in 1980.

Table 5.3

Forecast of number and size of computers required by Government in 1980

	Small	Medium	Large	Very Large	Total
Present	124	67	25	1	217
In ten years' time ..	55	48	48	108	259

Of the 108 very large machines there are:
(a) 76 equivalent to the 1906A
(b) 29 equivalent to the 1908A
(c) 3 even larger.

281 A two-fold weakness in forecasting on these lines is:

(a) some applications will be developed in the next ten years which are wholly unknown in 1969;

(b) some applications may prove to be more suitably undertaken by separate small or medium sized machines than, as we have tended to assume, by bureaux or multi-access computing.

Therefore, we have probably underestimated the *number* of separate machines which will be required in ten years' time.

Estimation of cost

282 We have found considerable difficulty in attempting to attach any sort of cost estimate to our longer term forecasts, for the following reasons:

(a) We could not establish a specific cost/performance ratio in order to adjust future estimates for the significant decline in the cost of central processor power expected in the next decade. The opinion has been expressed that such costs will fall to one tenth of their present level. A reduction of between 3 or 4:1 over the decade has been predicted for total hardware costs including peripherals. But this takes no account of the fact that more complex operating and applications software could reflect in increasing programming costs to the user, either directly or through increased manufacturers' prices.

(b) IBM Ltd has recently announced that it will price separately items of software hitherto included in the cost of the computer. This change will be accompanied by a 3 per cent reduction in the sale price of computers, but it has been estimated that users may have to pay up to 25 per cent more for the separately priced software. Until other manufacturers have made known their future policy on this matter the impact of this development on Government computing cannot be predicted.

(c) We cannot calculate the staff and other costs – eg on consumables such as stationery, punched cards, magnetic tapes – incurred in setting up and running an installation. All we know is that maintenance has been estimated as approximating to 5 per cent per annum of the capital cost of equipment. Staff costs, which form by far the largest item, depend on numbers, grades and pay, and we have insufficient detail to make any forecast based on such factors beyond 1974. We considered whether we might relate staffing figures to trends in power in order to get round this difficulty. We concluded that there is no useful correspondence. The staff requirement for a particular application depends in considerable part on such variable factors as its complexity and on whether similar work has already been undertaken elsewhere. Future staff requirements could therefore continue to be heavy even though the need for more power eases off.

(d) We cannot make provision for the fixed capital and annual rental costs of data transmission in the absence of firm and detailed plans for networks.

(e) We have no basis at this point in time on which to estimate the very substantial element of accommodation costs. For example, we cannot predict which applications will require new purpose-built accommodation and, if needed, whether it will be required only for the computer installation or for the whole complex of operations of which the computer forms part.

283 Because of these difficulties we have limited our estimates to the cost of hardware and have not attempted to achieve a precision in our costings which must, in the circumstances, be spurious. We have used historic cost for cumulative investment in computer hardware to the present time, and current (ie 1969) prices for future investment. We have not adopted the discounted cash flow method; and we have taken no account of residual values at the close of the ten year period.

284 On this restricted basis there is no difficulty in costing existing computer systems and those on order. The problem with our longer term forecasts is that we do not know which computer will be purchased for a particular task or what the peripheral requirement will be. To meet this difficulty we have based our costs on the classification of computers described in paragraphs 277 and 278, taking the mid-point of the class price range as the cost of computers falling within that range. This classification takes some account of the equipment, other than the actual processor, which makes up a significant part of the total computer configuration.

285 The following costs have been applied:

	Range	*Cost used*
Small computer	£10,000 – £99,000	£55,000
Medium computer	£100,000 – £499,000	£300,000
Large computer	£500,000 – £1,000,000	£750,000

The very large machines have a wide price range. We have therefore based our estimates of the cost of these machines upon the type of application and the estimates of cost made by MOD and Mintech.

286 We summarise in Table 5.4 the annual and cumulative net investment in computer hardware for administrative and scientific purposes in each of the six years 1964/65–1969/70. All values are expressed in £million rounded to the nearest £100,000, for the purchase (or rental equivalent) of computers and

peripheral equipment. Cumulative investment is net after writing off the historic cost of machines replaced. The cumulative figures for 1964/65 (Col. A, rows 1b, 2b, 3b) include all years previous to 1964/65. Values up to 1968/69 (Cols. A–E) are actual: the value for 1969/70 (Col. F) is a good estimate.

Table 5.4

Net investment in computer hardware for administrative and scientific purposes 1964/65–1969/70

		A	B	C	D	E	F
		1964/5	1965/6	1966/7	1967/8	1968/9	1969/70
1 Administrative	– (a) Annual ..	1·2	2·7	2·9	3·3	4·5	5·9
	– (b) Cumulative ..	6·7	9·4	12·3	15·6	20·1	26·1
2 Scientific	– (a) Annual ..	1·0	1·6	1·4	1·2	2·8	2·3
	– (b) Cumulative ..	2·0	3·5	5·0	6·1	8·9	11·3
3 Total	– (a) Annual ..	2·2	4·3	4·3	4·5	7·3	8·3
	– (b) Cumulative ..	8·7	12·9	17·3	21·8	29·1	37·3

287 Over the period 1964/65–1969/70 the rate of expenditure on computer hardware has increased at a lower rate (30 per cent per annum) than that of power installed (50 per cent per annum). This reflects the decreasing cost of hardware for a given amount of power. Both administrative and scientific machines have been close to this rate of 30 per cent per annum. Since the growth rate of scientific computer *power* has been slower than the rate for ADP (see paragraph 272), the improvement in the cost/power ratio has apparently been more pronounced on the administrative than on the scientific side.

288 Table 5.5 shows the forecast annual and cumulative net investment by Government on computer hardware over the ten years, 1970/71–1979/80. As we do in forecasting the future growth in computer power we distinguish between plans which are, and those which are not, clearly defined; and we include administrative and scientific computers in the one total. All values are expressed in £million, rounded to the nearest million, for the purchase (or equivalent rental) of computers and peripheral equipment. The cumulative figure for 1970/71 (Col. A, row 4) includes the 1969/70 cumulative value from Table 5.4. The rounding off accounts for the fact that the cumulative figures in row 4 do not exactly tally in every column.

Table 5.5

Forecast of net investment in computer hardware for administrative and scientific purposes combined, 1970/71–1979/80

	A	B	C	D	E	F	G	H	I	J
	70/1	71/2	72/3	73/4	74/5	75/6	76/7	77/8	78/9	79/80
1 Plans clearly Defined – Annual	11	16	26	11	2	4	15	8	13	20
2 Plans not clearly Defined – Annual ..	—	—	—	4	6	12	14	11	20	24
3 Annual Total ..	11	16	26	15	8	16	28	20	33	43
4 Cumulative Total ..	49	65	90	105	113	129	157	178	210	253

289 We are thus forecasting a total net investment in computer hardware of some £250m by 1980, about £220m of it after June 1969 at 1969 prices. The respective gross figures are £300m and £270m. This represents an eight-fold increase over ten years compared with the fifteen-fold increase for power. This difference is attributable primarily to the better cost/power ratio given by the larger machines. We have not been able to make an adjustment for the effect of general technological development.

290 The application of computers to the work of Government is still at a comparatively early stage. This accounts for the high growth rates forecast in this Chapter, particularly in the first half of the 1970s. It would appear from a comparison with an estimate of the national growth of computers in the UK made recently[5] that the rate of growth in Government is at present somewhat higher than the national average. It also appears, if our forecasts are broadly correct, that the high rate in Government is likely to continue longer than in the UK as a whole. But this national estimate is in general accord with our prediction of a continued high rate of growth in the use of computers in Government throughout the 1970s.

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[5] This estimate was made by the Hoskyns Group and reported in the Financial Times, 10 September 1969, page 11.

6 Personnel

291 In the preceding Chapter we have attempted to forecast further developments in computing in Government and to quantify these forecasts in terms of computing power. But these developments are wholly dependent upon having high calibre, experienced specialist staff available in the number required at the right time. We consider in this Chapter what these requirements are, how they can be met and the implications of this demand for training facilities. We assess also the probable impact of these developments upon Civil Servants outside the ranks of the ADP specialists.

Extent of the review

292 In the past, Government's ADP projects have been developed and operated primarily by the General Executive Class.* The measure of success achieved by the early applications is a testimony to the ability of these officers, many of whom were pre-, or immediate post-, war entrants with invaluable knowledge of departmental procedures.

293 Some of the most important and successful computer installations in Government are, of course, those used primarily for scientific and research purposes. These have been developed and operated by the professional, scientific and technical classes with support from the Executive Class on administrative aspects. In the time at our disposal we have had to concentrate on staffing problems in the field of administrative and general purpose data processing. Our contacts with the departments mainly concerned with scientific computing suggest, however, that their staff problems are basically the same as those in ADP, though on a smaller scale and concentrated mainly at the junior programming and operating levels. Fewer staff are involved[1] and they tend to be split up in small numbers between installations. We therefore consider that the recommendations we propose for non-scientific computer specialists can be applied broadly to their scientific counterparts.

294 Within ADP our prime concern has been with systems designers and programmers[2] at all levels, and with senior staff who must at some stage have had experience in this work: these are the critical staffing areas. We refer only

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* The pay of the grades in this class is shown in Appendix 4.

[1] At 31 March 1969 there were 1,766 systems designers and programmers engaged on administrative computing compared with 222 on scientific work.

[2] Recommended titles are contained in the Ministry of Technology's booklet 'Staff Titles and Job Descriptions in Commercial Data Processing' published by HMSO 1967.

briefly to operating and data preparation staff. Though the turnover at the basic machine grades can create local recruitment problems we found no evidence that departments generally were having difficulty in getting the operating staff they wanted. We do not consider computer centre managers, or officers responsible for the organisation of the computer room or for data preparation, except briefly in reviewing training. This is because these posts do not necessarily have to be filled by systems designers or programmers. Nor do we consider staff for computer maintenance.[3]

295 We use only two terms to describe staff in the critical categories: systems designer and programmer. Within the term systems designer we include all staff who are engaged in the analysis and in the design of the whole or part of a computer-based system. It thus embraces systems analysts, systems designers, and advanced systems designers who, broadly, are high calibre people with considerable experience in special aspects of data processing. This definition therefore recognises the fact that the design of a computer system is a series of interconnected and related processes. The existing system is analysed, a job specification drawn up and an outline design for a computer-based system produced. Detailed working documents are subsequently prepared which the programmers convert into a series of instructions to the computer (program). There is no hard and fast distinction between the various functions, and hence between the people carrying them out. Some departments will merge the functions of programmer and analyst, or analyst and designer. Correspondingly, while Executive Officer (EO) is generally the basic grade for programmer, and Higher Executive Officer (HEO) has been the main grade for systems analyst and designer, the position varies considerably from department to department and from application to application according to the scale and complexity of the design and programming work involved.

Forecast of staffing requirements

296 In attempting to estimate future requirements, particularly for systems designers, programmers and senior staff with experience in these specialisms, we have had to rely primarily upon the annual staff returns of departments to CSD for the year to 31 March 1969. These include estimates of future requirements for each year to March 1974.

297 We have not been able to get any specific information from other sources. The unanimous opinion of the experts outside Government whose views we have sought is, however, that it would be utterly unrealistic to attempt to forecast ADP staff requirements in ten years' time, and that reliable forecasting is difficult for more than three or four years ahead. But not one expects that numbers will drop over the longer term even though the rate of increase may slacken. At the same time the increasing complexity of the new systems will demand a marked improvement in the quality of staff required.

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[3] The greater part of computer maintenance in Government is carried out by the manufacturers under contract. This is in accord with general commercial practice.

298 These opinions are endorsed by the Manpower Research Unit of DEP on the basis of a preliminary analysis of the results of the recent survey it has conducted to bring up to date its publication, 'Computers in Offices'.[4]

299 The departmental forecasts made in March 1969 for the years 1970/74 for staff employed on ADP have been plotted on a graph against the forecasts made on the same basis in each of the three preceding years. The actual in-post figures for the years 1958 to 1969 have also been shown (see Table 6.1 opposite).[5] Because we are concerned primarily with systems designers and programmers we have extracted in Table 6.2 figures for these categories, with administrative and executive, military, and scientific personnel separately distinguished.

Table 6.2

Estimated requirements for ADP systems designers and programmers, 1969/1974

Year to 31 March	*Admin/Exec Staff*	*Military*	*Scientific*	*Total*
1969 (Actual) ..	1,766	195	222	2,183
1970	2,381	204	335	2,920
1971	2,582	207	364	3,153
1972	2,562	252	385	3,199
1973	2,585	251	405	3,241
1974	2,557	242	408	3,207

300 The figures in Table 6.2 make significant comparisons with those forecast in earlier years. Thus, at 31 March 1967 there were 1,315 staff (administrative/executive and military) employed as systems designers and programmers compared with 1,961 at 31 March 1969. In 1967 the peak demand for these staff was put at 1,850, to be reached in 1969: it is now estimated at approximately 2,800 in 1973. Very little of this remarkable increase can be attributed to work in connection with decimalisation. Departments will require an additional 106 ADP staff for decimalisation and this number is included in the March 1969 totals.

301 The graph in Table 6.1 indicates that, as the early 1970s draw nearer, departments are able to make a better estimate of their staff requirements for these years than they could at an earlier point in time. In particular, they are beginning to assess the full implications in terms of staff of some of the major systems now being designed. The graph also reflects a marked tendency to serious under-estimation which is greater the longer the forecast period. The precise source and explanation of this under-estimation has not been isolated. Because of the importance of the annual forecasts for ADP staffing policy – and so for the success of future projects – we recommend that, as part of its personnel service, MS(C) Division, CSD, should make a closer study of departmental forecasting methods.

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[4] Manpower Studies No. 4 (SO Code 36–283–4).

[5] The figures plotted on the graph include headquarters ADP units, project managers, systems and programming staff. They exclude operating and data preparation staff. Because returns in previous years did not distinguish military personnel these have been included in the 1969 projections to achieve uniformity. Their contribution ranges from 210 in 1969 to 275 in 1974. Scientific and technical staff have been excluded because departments made their first returns for these officers in 1969.

302 We do not believe that a plateau will be reached by 1972 or 1973 as the graph suggests, though the growth rate must drop below the mean value of 30 per cent per annum maintained between 1965 and 1969. We accept that certain factors will make for a reduction in numbers. Many of the big clerical processes in Government, involving massive file conversion, have now been computerised: the greater use of high level languages and the development of computer assisted programming could substantially increase the output of the programmers: the use of standard program packages – eg for payroll or inventory – will also cut requirements. But we consider that these reductions will be heavily outweighed in the 1970s by increasing demands, because departments generally underestimate their longer-term ADP requirements. We were told that they are reluctant to make advance provision for projects which cannot clearly be anticipated. We know that they have not taken into account the staffing implications of the longer term possibilities which we outlined in Chapter Three, or the still more substantial demands of management information systems.

303 In the main departments have tended to overlook or under-estimate:

(a) the extent of redesign work involved in the replacement of existing computers, especially when the original system is simultaneously being extended or refined;

(b) the job of program maintenance, particularly for functions affected by legislation.

304 ADP complements need to be built up to provide adequate margins for staff training, for effective career development (to which we refer later) and for the advance planning of future ADP applications. As we have indicated in Chapters Three and Four virtually no department has sufficient ADP staff available to have any prospect of withdrawing senior officers from projects in order to plan ahead. This has been true of departments with central responsibility, eg CSD, CSO, Mintech, as well as of those with purely internal responsibility.

305 Overall ADP staffing policy – on selection, training, remuneration and career prospects – must take account of wastage as well as growth: and the trends are ominous. If the present rate of wastage of Executive ADP staff continues it would amount to some 250 a year by 1971. This would make it difficult for departments to maintain progress on existing projects and impossible for them to build up the number of experienced staff necessary to undertake future commitments.

306 Statistics for wastage are available only for the Executive Classes. Sixty per cent of all General Executive staff employed on ADP who resigned during 1968/69 were aged 24 or under. The percentage for EOs was 65 per cent. The breakdown between HEO and EO of the losses by resignation in 1968/69 is shown in Table 6.3.

Table 6.3

Losses through resignation of ADP staff at HEO and EO level, 1968/69

Grade	*Approx. No. of ADP Staff in Post at 31.3.67*	*Approx. No. of ADP Staff in Post at 31.3.68*	*Losses* 1.4.68–31.3.69*	*Losses as[6] Percentage of staff at 31.3.67*	*Losses as[6] Percentage of staff at 31.3.68*
HEO	363	388	6	1·7	1·6
EO	517	745	87	16·8	11·8

* Losses during 1968/69 have been compared with the staff in post at 31.3.67 as well as at 31.3.68 because ADP staff do not normally seek outside employment until they have had one or two years' ADP experience.

307 The conclusion to be drawn from these figures is, it seems to us, inescapable. The percentage of losses by resignation in 1968/69 was substantially greater than in the previous year and almost twice that in 1966/67; and the number of EOs resigning to take on other ADP posts has, during the past two years, exceeded the number transferred from ADP to other duties. The rate of wastage among Executive Class ADP staff as a whole is higher than for the Executive Class generally. Furthermore, wastage is higher among the younger than the older staff, and the rate of loss of EOs on ADP is significantly higher than the rate of loss of Executive staff under 24 generally.

308 The gravity of the situation is to be measured not only by the present rates of wastage. The losses of ADP specialists at EO level are staff with upwards of one and generally two years' experience and with detailed knowledge of a particular application. These losses cannot therefore be made good within a relatively short space of time, as can losses among staff engaged on general duties, by moving in a general service officer from another job. Moreover, while the losses by resignation at HEO level are at present relatively low we consider that, unless action is taken now to improve career prospects, they are likely to increase sharply when transferability of pension rights is introduced.

309 The rate of wastage on resignation varies in different parts of the country and from department to department. It is heaviest where, as in London and Newcastle-upon-Tyne, substantial numbers of commercial and industrial concerns are increasingly making use of computers: in such situations wastage among EOs is now running at four times the 1968 level. It is also heavy in departments where promotion prospects within ADP for EOs appear to be poor. There are several inter-related reasons for the wastage. There is strong evidence that the younger and junior staff resign to get more pay: few EOs in their early twenties will resist the temptation to pick up, as they now can in many big centres, between £300 to £500 more per year plus substantial fringe benefits. But people also resign because they are dissatisfied with their career prospects within the specialism. This is again partly a question of

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[6] These percentages may be compared with the wastage rates for various age groups of male General Executive Class permanent staff:

Age-group	*Percentage Wastage*
30–33	1·2
25–29	3·5
20–24	8·7

money, since promotion means an increase in salary. It is also a matter of job satisfaction since most ADP systems designers and programmers are continually looking out for interesting and challenging jobs.

310 This situation is not peculiar to central Government. It arises also in the commercial world where concerns tend to meet it in two ways. First, they recognise that they must give able programmers relatively substantial pay increases in their first two to three years if they are to retain them. They justify this on the grounds that it is cheaper than having to write off the investment in training an ADP specialist. Depending on the basis of calculation, and the form and length of training, this is estimated at between £1,000 and £4,000. The corollary to this is that staff who do not reach an acceptable standard are ruthlessly weeded out of the ADP unit. Secondly, they recognise that ADP staff are a valuable commodity to be carefully managed and deployed. They therefore devote considerable time at relatively high levels of management to reviewing the progress and performance of systems designers and programmers and to seeing that the work of the better staff is regularly varied and improved in quality.

Future policy

311 It might be argued that, in view of the stringent restrictions upon Civil Service manpower at the present time, it would be a legitimate risk to work on the assumption that the future demand for ADP specialists will in fact reach a 'plateau', or even decline, by the mid 1970s as the departmental forecasts have suggested. On this assumption the line could then be held broadly at its present position without any special provision being made to improve the flow of experienced ADP staff into departmental project teams, or to staunch the losses. Immediate problems would have to be contained until, on the hypothesis, supply catches up with demand in four or five years' time.

312 We cannot accept this line of reasoning. It disregards entirely the factors to which we have referred in paragraph 302 to 305 and the implications of the forecasts in Chapter Five. It ignores the critical situation which already exists in some departments. It would, on our view of the future, mean that Government will not have the trained and *experienced* staff it will need for the advanced projects now in prospect for the 1970s, at the time it must have them. There can be no question of mounting a crash programme to produce the necessary specialists at short notice if, in a year or so, the hypothesis is demonstrated to be false. Planning for the future must start without delay and this alone means more staff now. Experience is essential in ADP: it can be acquired only over years and must be conserved. Moreover, as we will argue later in this Chapter, an expanded training system, capable of meeting the increasing need for better equipped staff, must be developed now if it is to meet the demands of the future.

External support

313 The alternative to adopting now a positive policy for improving ADP career prospects and building up within Government ADP units of the size and quality needed to undertake future projects, would be to accept that either the whole or a very large part of Government's ADP should be put out to external organisations. The arrangement might be to hand over the work to an

independent or semi-independent agency which would be outside the manpower constraints and the pay structure of the Civil Service. Alternatively, or in addition, complete design projects and operational functions could be placed with commercial enterprises.[7]

314 We do not regard this first possibility as an acceptable alternative. It is certainly not one which appears to have been adopted by other Governments with numerous ADP applications on the scale of those of the UK Government;[8] and it is not favoured by the large commercial and industrial concerns in this country which make extensive use of computers for ADP. The general view is that a majority of the staff designing a computer-based system for a particular concern need, if it is to be successful, to be experienced in the work to which the computer is to be applied; and it is more effective to train some of the staff of the concern in ADP than to give ADP specialists the necessary knowledge and experience of the firm's business. Other serious disadvantages would be:

(a) the department which is responsible for the procedures being mechanised would lose an important measure of direct control of its affairs and could be left in a dangerously exposed position;

(b) the department may find it difficult to build up its own ADP expertise and experience so that it can take over or expand on the contracted job if it should wish to do so;

(c) Government could lose close contact with the manufacturers and have no direct negotiating position with them, either on price or on specialised hardware and software developments for its own requirements.

315 Nor do we accept the second choice that, as a regular policy deliberately adopted to cover staffing deficiencies, Government should put out a significant number of its ADP projects to commercial concerns. This alternative has some of the disadvantages to which we have referred in the preceding paragraph. Moreover, ADP expertise is an expensive commodity to buy even when it can be obtained. It costs £20–£30 per day to buy-in an experienced programmer. Even the manufacturers charge upwards of £12 a day for inexperienced programmers who have just completed their formal training, and departments have had some unhappy experiences with support of this kind. At the other end of the scale systems analysts and consultants can cost upwards of £40 a day.

316 External support will obviously be necessary from time to time. Government departments do not have the freedom to emulate commercial concerns and buy-in one or two carefully chosen individuals at very high salaries to fill key posts within their organisation. In our view this support should be sought only in special circumstances where expertise in a particular subject is not available within Government or where trained staff cannot be found to undertake a particular project or section of a project. For example, there are special circumstances in the London Airport Cargo Electronic data processing scheme (LACES) which will be operated by NDPS on behalf of Customs and

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[7] There are basically three categories of external support available: (a) where the provider undertakes the whole operation – ie a 'turnkey' operation; (b) where the provider works jointly with the customer on the whole operation – ie 'controlled turnkey'; (c) where only certain services are supplied.

[8] Some of the Scandinavian countries, and Belgium, operate semi-independent agencies as bureaux for Government computing.

Excise, the airlines and forwarding agents. Again, MOD may need external software support for the design of the on-line real time system for Air Force stores at Hendon because the necessary expertise is not available within the Service.

Satisfying future requirements

317 In framing our proposals on this subject we are assuming that, in future as in the past, the policy in Government will be to find from its own resources the great majority of the specialists required to design, program, implement, and operate its computer systems.

The resources required

318 Complex systems like those of DHSS, Reading; the Home Office police records; HMSO, CCB Norwich; and MOT, Swansea, demand staff of high calibre with extensive experience. So too will integrated systems extending across branch and departmental boundaries. These developments will mean a change in the balance of skills required by ADP specialists. They will certainly not reduce significantly the contribution of the present Executive Class to Government ADP. Many of these officers are qualified on all counts to undertake advanced work; and staff from this source will still be required in large numbers as the backbone of programming and systems effort. Increasingly, as university education expands, we would expect that ADP staff will be found from the graduate intake. The general need for a wider graduate entry to the Service is now under active consideration.

319 They will, however, have to be reinforced from within the Service by officers of good graduate calibre, with the necessary aptitudes, brought in from a number of specialisms. This support should include staff from the present administrative grades (eg young Principals). The very limited involvement of the Administrative Class in the development of computer systems has in the past undoubtedly been a weakness in Government's ADP effort. Scientific and other specialist groups including statisticians and economists should also contribute. We would hope that, in this way, some scientists would be helped to get a wider knowledge of the work of Government and so, possibly, towards wider career outlets. Finally, the highly developed skills of establishments like the National Physical Laboratory (NPL), the National Engineering Laboratory (NEL), the Royal Radar Establishment (RRE) and the Programmes Analysis Unit (PAU) should be available on a systematic and coordinated basis to advise departments on particular aspects of their advanced applications.

320 Some of these people will already be specialists in particular aspects of ADP. Others will bring to bear experience of particular aspects of departmental work on difficult problems of systems design. They will increasingly work together in project teams with officers from other specialisms such as O & M and OR.

Assembling the resources

321 We are generally satisfied that resources of the appropriate quality can

be found within Government. But this is no cause for complacency. The resources will not become available where they are most needed simply by stating the requirement. An intensive effort will have to be mounted first to develop an adequate career or part career for able officers within ADP and then to convince these people that their long term prospects will not be prejudiced by service in ADP. An equally intensive effort will be needed to persuade departments that their interests will be best served by cooperation in the venture. Departments and branches are understandably reluctant to release to other projects specialists whom they have trained and retained against competition from commerce and industry. Again, there is evidence that senior staff in some departments discourage specialists (eg scientists) from participation in ADP, using the argument that their future as specialists will thereby be prejudiced.

322 It will take some time to mount this effort and to produce the desired results. The people who are attracted into ADP will need training or further training – eg as computer scientists – before their potential can be realised. It will be in this interim period particularly that, on occasion, no one will be available within Government with the expertise necessary to attack a particular computer problem. It is in this situation that external specialists will have to be brought in either as consultants or on contract. To get the right people, salaries related to the present high market rates will have to be offered.

323 There are essentially three problem areas affecting personnel: pay, career development, and training (which we review separately). Unless solutions are produced speedily the whole foundation upon which Government computing must depend will be in serious jeopardy. A realistic answer must be found immediately to the problem of matching the pay of the Executive Officer (EO) programmer and junior analyst with that which these specialists command outside the Service. As we have said, the intolerable wastage at this level is primarily a question of money. The development of a satisfactory career for programming and systems staff generally in ADP, which is vital if Government is to build up its resources of experienced specialist staff and deploy them effectively, must take longer to achieve in full: but this work too must be pressed to a conclusion as quickly as possible.

Pay

324 We are in no doubt that what is wanted is a realistic adjustment to the EO scale given openly for market reasons, as an incremental progression within the scale. These advances could be implemented as a prerogative of management: they would not be negotiable, and would be subject to withdrawal if the justification disappears. The advances could be made in two stages after, say, one and two years effective service in ADP as a programmer or junior analyst.

325 The assessment of performance for this purpose must be made by project managers and their job will be greatly facilitated if general standards of performance can be established. This is a difficult task but it is being tackled by computer users in the commercial sector and we recommend that CSD should give priority to it. It is the sort of job which could usefully be undertaken by the ADP training unit. But initially, because of the limited number of instructors, it must fall upon MS(C) Division.

326 An improvement in pay will not entirely eliminate the wastage of programmers at EO level. Some commercial concerns will always be prepared to outbid Government in order to overcome shortages which impede development. Furthermore, improvements in pay, though vital at this level, will provide only a partial answer. The problem of job satisfaction as an officer grows in experience must also be tackled, and we suggest that two measures would improve the situation in this respect:

(a) The type of work on which an officer is employed should be varied at intervals of not more than 18 months. Some departments are at present remiss in doing this.

(b) Departments should adopt a measure of flexible complementing coupled with a system of temporary promotions, starting at the Clerical Officer (CO) to Executive Officer (EO) level, so that they can promote proficient officers at an earlier age than is possible under general rules. This remedy has been adopted with good results by some departments: it is a means of giving good officers more money and better quality work as soon as they merit these improvements. The need for a solution on these lines would presumably disappear if, as part of the post-Fulton reorganisation, an integrated structure is introduced with standard provision for accelerated promotion.

Career development

327 To be successful a systematic pattern of career development in ADP should have two main objects:

(a) to attract able officers of all disciplines and at various levels into ADP by satisfying them that a part or full career in this field will not place them at a disadvantage as regards their contemporaries who continue on general or specialist (eg scientific) duties.

(b) to retain trained ADP officers on this work for a minimum of five years and to develop the best of them either for senior ADP posts in departments – eg as computer centre managers or project leaders – or for ADP work in some specialised field in departments or with MS(C) Division, CSD.

328 The career pattern must take four important considerations into account:

(a) ADP work requires a substantial number of programmers and more junior systems staff, and provides a relatively small number of senior posts. Because of this broad base it is not possible to provide a full career for all staff in the specialism. Provision must therefore be made for the movement of staff out of ADP and into other jobs. The point in time at which particular officers leave ADP will be determined in part by their career requirements and in part by the need to keep trained ADP staff in the specialism for at least five years, and preferably more, in order to capitalise reasonably on their training and growing experience.

(b) Officers who leave ADP after five years, and more particularly after longer periods at more senior levels, are entitled to expect a thorough and carefully devised form of conversion or assimilation training to bring them abreast of the latest developments in their departments and original specialisms. This will be of particular importance in those departments where legislation is continually changing and growing increasingly complex. Without it officers will lack confidence in their ability to cope effectively on their return to general duties – and will be deterred at the outset from entering ADP.

(c) At present those working in ADP distinguish unfavourably the situation in Government from that known to prevail in commerce and industry, where service in ADP is recognised as valuable experience for the senior managers of the future. The provision of assimilation courses would be a tangible indication that departments do not regard extended service in ADP as a disqualification for high level work outside the speciality.

(d) Staff employed in ADP must be satisfied that their suitability for further advancement in the specialism will be assessed primarily on the basis of their performance on ADP work though, in considering suitability for the more senior posts, general qualities (such as power of expression and leadership) will obviously have to be taken fully into account. This underlines again the need to develop generally-recognised standards of performance. It means also that promotion boards must include senior ADP officers.

329 In paragraphs 330 to 339 we make proposals for satisfying the requirements.

330 Outside scientific computing the bulk of programming staff should continue to be selected from what at present constitutes the Executive Class and corresponding departmental grades. Officers with a minimum of two 'A' levels, or equivalent qualification, will initially form the bulk of the intake at about the age of 20 though, increasingly, we would hope that some of an expanded graduate intake will start in ADP as programmers. There should also be scope for bringing into programming suitable clerical staff, senior machine grades and some older EOs with the necessary aptitude, in order to provide a suitable balance of age and stability. Officers within these categories should therefore be given the opportunity of applying for aptitude testing. Where no vacancies exist in parent departments officers should be allowed to transfer. If it proves necessary, the policy of employing only volunteers on ADP might be modified to the extent of drafting potentially suitable officers into ADP unless they object. But the evidence suggests that it would be wrong to press into ADP staff who are reluctant to take on the work.

331 The 'deskilling' of programming work so that the basic elements can be assigned to staff below EO is a useful stepping stone for entry into ADP. Some departments are already doing this. Others should examine the possibility of adopting the same course for their projects.

332 The types of aptitude test currently in use in Government urgently need to be reviewed, improved, standardised and applied systematically across the Service to all new entrants, and to those already serving who wish to be considered for systems or programming work. This will be difficult, primarily because the lack of general standards makes it difficult to follow-up effectively the subsequent progress of those who have taken the present aptitude tests, but research within the Service is making disturbingly slow progress. The National Institute for Industrial Psychology is studying the problem in regard both to programmers and systems designers, and there are developments by commercial concerns. We recommend that the Civil Service Commission in conjunction with MS(C) Division should join actively in this research.

333 The progress of systems designers and programmers must be carefully monitored and shaped, through an improved system of job counselling. CSD should take the lead in fostering this development. In large departments with several ADP units the central unit should see that the necessary arrangements are made, and assume general responsibility for ensuring that staff are developed and deployed to the best advantage. In these ways Government will follow commercial practice, which increasingly recognises the need to husband and develop scarce resources accounting for upwards of 60 per cent of the total annual expenditure on computers. The object will be to vary the work and increase the experience of all staff, partly to increase job satisfaction but, more important, to mark out and groom the most able staff who will provide the senior ADP staff and the team leaders of the future. The development of these officers of high potential will include a mixture of varied practical experience and extended training, both in-Service and external, including univerisity and HND courses. The frontiers of computer technology are advancing rapidly and the specialist knowledge of the best practitioners must be continually updated and expanded in this way. A margin on complements will be essential if staff are to be released for further training. The point at which officers are selected for external courses must have regard to the nature and grade of work which they will be expected to undertake on return to their department or on transfer to MS(C) Division, CSD.

334 This raises the question of the significance of external qualifications acquired by ADP specialists, such as the British Computer Society's diploma which is available to systems analysts who pass the examination which concludes the National Computing Centre's systems analysts' course. We generally welcome developments of this kind as marking the growing professionalism within ADP. It should help to improve the quality of systems design within Government.

335 After a period of about five years, and again after a further period of five years or so, systems designers and programmers should in consultation with their departments be given the opportunity either to return to general duties (or to their non ADP specialisms) or to continue to serve in ADP. The object will be to retain the best longest, and to develop their careers in ADP to the general advantage of the Service. The senior ADP posts[9] both for particular projects and at departmental headquarters should be filled in part by selection from within departments, so that the necessary amount of general departmental experience is retained. But there should also be some switch of staff between departments either on secondment or transfer so that skill is deployed to the best advantage.[10]

336 Some of the most proficient staff will develop into specialists in particular aspects of computing and be available, in an advisory capacity, either on loan from their own departments or after transfer to CSD, to other departments which are introducing advanced applications. There will be opportunities in MS(C) Division CSD both at Senior Executive Officer (SEO) and Chief Executive Officer (CEO) (or equivalent) level in particular subjects (eg infor-

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[9] eg team leaders; chief programmers; advanced systems designers; computer centre managers.

[10] The exchange of staff has already begun in a small way. Some DEP staff are working with DHSS, Reading, on putting the payment of unemployment benefit on computers.

mation retrieval; real-time systems) and at CEO and Senior Chief Executive Officer (SCEO) level (or equivalents) in charge of one of the branches or groups. Gradings will have to be regularly reviewed, of course, to take account of the growing skill and responsibility of these posts.

337 It will not in future be possible to fill adequately all the more senior posts in ADP from among staff who are spending a substantial part of their career in the specialism. This source will have increasingly to be supplemented by an infusion of, for example, scientific officers who have skills in particular aspects of computing and Principals (or their equivalents in specialist grades) who can be expected to contribute effectively to systems design for a period of about five years, and whose service on this work will be generally recognised as a valuable stage in their career development. This should not be a one-way traffic. For example, as scientists move into ADP so experienced practitioners with an Executive background must be recognised as candidates for the management of certain scientific installations. This will require a change of policy in some scientific establishments.

338 We recommend, finally, that there should be a review by CSD of the grading of ADP posts in departments on a Service-wide basis, accompanied by a sharper definition of duties. We formed the strong impression during the course of our review that there is considerable disparity between the levels at which broadly comparable duties are carried out in different departments. A regrading would provide several benefits. It would remove a present cause for discontent among ADP staff. Generally we believe that it would yield a favourable balance of upgradings and so improve promotion prospects and further reduce the present pay differential between ADP staff employed in and outside Government. In particular it would identify posts at present filled by EOs which should either be regraded High Executive Officer (HEO) or, at least, should qualify for a responsibility allowance. Under present conditions temporary promotions might be necessary in some cases if the normal promotion pattern in particular departments is not to be distorted: and some officers might have to be transferred from their present units or departments. The information obtained from the exercise would also provide the necessary basis of fact for allocating particular posts to the people best qualified to fill them irrespective of their background (eg executive; scientific; departmental class).

339 Our proposals for the more effective deployment of ADP staff so that they may be used to maximum advantage are subject to one severe practical limitation. This is the reluctance of many staff, even at comparatively senior levels, to accept a job in another department or another area which involves a change of residence, except on promotion or with the clear assurance that the change will improve their career prospects. This underlines the imperative need to attack the ADP staffing problems comprehensively and on a realistic basis. Our proposals must be taken together. We are in no doubt that an attempt to tackle the matter piecemeal is foredoomed to failure.

Attachment of ADP staff to departments

340 The arrangements we propose would continue to rest on a departmental foundation. The bulk of ADP staff in Government would continue to be

recruited through the normal channels and, in the main, would be grounded in the work of their respective departments before branching out into ADP. In our view this is essential if they are to bring with them into the specialism the departmental expertise which most of them will continue to need. It is also necessary so that, for some of them at least, departments can provide the career outlets at higher levels which ADP cannot provide.

341 The departmental link would not necessarily be a permanent one. Thus, where there are no ADP vacancies in the parent department, officers with the necessary aptitude who wish to move into ADP should be allowed to transfer to departments which need them. Again, when a particular project comes into operation some of the staff who designed the system, and who wish to remain in ADP, may elect to move on to a new project in another branch or department and should be helped to do so. Recommendations on these lines were in fact made by the inter-departmental working party on the recruitment of ADP staff which reported in 1967. Finally, as we have stressed, more senior staff with special ADP expertise should be deployed across the Service to the general benefit of Government.

342 Flexible arrangements on these lines will depend very much on departmental cooperation. Our proposals would in some measure replace the present 'trawling' arrangements to which some departments are bitterly opposed, and should go some way towards winning departmental support. So should some of the other proposals we make in this report. For example, the coordinated planning, well in advance, of future ADP applications should help to ensure that the staff needed to implement them are on hand when required. The willingness of departments to release more senior specialists for service in other departments, or with MS(C) Division CSD, will depend on departments being allowed adequate margins on their basic ADP complements to provide for career development of this kind. If departments have the authority and the time in which to select, groom and train replacements for the senior staff required for Service-wide postings then, from what they have told us, we believe that they will cooperate.

343 The requirements of career management, the effective deployment of staff, and the need for common standards in such matters as grading, performance and training, must impose upon this basically departmental structure a degree of central coordination and guidance. This should be achieved through the wider involvement of CSD in ADP staffing problems across the whole Service. The effective participation of MS(C) Division, CSD will be particularly important in ensuring that the more able officers get the experience and training needed to develop their full potential, and that they are used to maximum advantage. For this purpose departments will have to inform CSD of the careers and qualifications of their best people, starting at the most senior levels, so that an up-to-date register can be compiled and maintained for the benefit of the Service at large. As a corollary to this, the problem areas in particular applications will have to be carefully defined at an early stage so that the specialists capable of resolving them can be made available.

344 We do not think that it would be worthwhile extending this register to cover all systems designers and programmers. It would be laborious to maintain and would not materially improve the arrangements we propose in paragraph 341.

An occupational group for ADP staff

345 Whether or not the arrangements we propose amount to the creation of a separate occupational group for ADP staff (or more probably for defined categories of specialists within the total number wholly employed in connection with ADP) will depend on the precise way in which these groups are eventually formed in the Service generally. The arrangements do seem to have some of the characteristics of an occupational group as we understand the term; there would, for example, be career specialisation for a varying number of years and in most cases through several grades depending on the time which particular officers spent in the specialism. On the other hand we propose a separate pay adjustment only for the EO grade and do not recommend separate recruitment.

346 On balance we consider that the creation of a formal occupational group for ADP staff could impose an undesirable rigidity on what should be a flexible system. It could create difficult problems of job description and impede the free flow of staff in and out of the specialism in the way we believe to be necessary. The inclusion of ADP staff in a group formed for management services generally would obviously improve career prospects: but we doubt whether it would achieve the advantages to be obtained from providing outlets into the general work of departments in the way we propose.

Operating staff

347 In reviewing personnel we have concentrated on systems designers and programmers because there are problems concerning these staff which, if unresolved, could jeopardise the whole future of ADP in Government. This is not to minimise the importance of the work of the data preparation staff and the operators – the machine grades[11] and the COs, EOs and HEOs who operate the consoles and control the progress of work through the computer room. It simply signifies that, with only a few exceptions – eg scientific computing in MOD – the provision of operating staff in the number and of the quality required has presented no major problems. The main concern is to provide outlets for the experienced machine staff with the potential for higher calibre ADP work.

348 There is, however, a growing body of opinion that, with the larger third-generation computers and their advanced operating systems, the operating job is itself becoming more complex. This must reflect in the calibre and grade of officers employed on the work and on the training which they are given. This prediction is borne out by the provision being made by at least one large commercial concern, with extensive computer facilities, for its operating staff. They get a year's training covering all aspects of operating work and then form operating teams made up of people 10 per cent of whom are graduates, 30 per cent hold HNDs and the remainder are of 'O' level standard.

349 In view of these developments we recommend that the grading of operating staff should be reconsidered by CSD. This could help to provide better

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[11] Machine Assistants (MA's) are normally employed on data preparation. Machine Operators (MO's) employed on computer operations change the tapes, feed the cards, service the printer, etc. Senior Machine Operators (SMO's) supervise the MO's, keep records and, in some installations, look after the console.

career prospects for them. This is a limited problem, primarily because relatively few of the junior machine grades are concerned with full careers. Improved training, which we examine subsequently under that general heading, should help officers with the necessary aptitudes to progress into advanced operating, programming or systems design. The line of advance might be further strengthened if those machine staff who are associated with computer operating are taken out of the general machine grades, and we recommend that this possibility should be considered in depth.

350 There is a special problem concerning data preparation staff. As we pointed out in Chapter Three the introduction of Optical Character Recognition could reduce the demand for keyboard operators, though it will not eliminate it. The high turnover of these staff will reduce the problem of redeployment but we recommend that early attention should be given by CSD to the implications of technical progress both for the staff concerned and for the future organisation of data preparation work. The object will be to avoid redundancy and to equip the staff with the skills needed for new processes.

Shift working

351 Agreement has now been reached with the National Staff Side on the operating of computers on a three shift basis for up to 120 hours per week. A review is currently being made by CSD of the way in which this agreement is working in practice and it would be premature for us to make any firm recommendations until the results of this detailed survey have been analysed.

Training

352 Thorough training lies near the heart of effective ADP effort. This appears to be wholly accepted by commercial undertakings which use computers extensively. They therefore devote considerable resources to the training of systems designers and programmers in the numbers and with the skills required successfully to develop their computer applications. The importance of training is also acknowledged in the Civil Service, and the Management Services (Training) Division (MS(T))CSD has in fact recently reviewed ADP training arrangements in consultation with departments to pinpoint the deficiencies and decide how best the improvements sought by departments can be achieved.

Present arrangements and developments

353 The categories of staff for whom training courses either are or are to be provided, are:

(a) programmers and systems designers (including analysts);
(b) computer centre managers;
(c) computer project managers;
(d) operating staff;
(e) data preparation staff;
(f) general management (appreciation courses).

354 The developments now planned as a result of the review which has been made are:

(a) *Programmer*. Training must be a mixture of theoretical and on the job training with the trainee working progressively and under supervision from simple to more advanced work. At present MS(T) Division CSD runs only a two week introductory (ie pre-programming) course and no program language courses. Departments want more introductory and pre-programming courses: there is a demand for 500 places in 1970. But more staff are needed by the MS(T) Division CSD if it is to meet the demand. Program language courses have hitherto been provided by the manufacturers, and departments have found them of poor quality and not oriented to Service requirements. The general view is that the Service should develop its own program language training courses both centrally and through those departments (eg MOD; DHSS; Scottish Office) which currently run their own courses. These departments are prepared to open their own courses, possibly on a regional basis, to other departments. MS(C) Division CSD will coordinate. MS(T) Division CSD is considering the possibility of mounting a combined theoretical and practical course in ICL-oriented courses when terminals are available to CCB, Norwich. If internal program language training cannot be provided (eg because of staff shortages) then CSD will try to ensure that the manufacturers' courses are Service-oriented.

(b) *Systems designer*. At present MS(T) Division CSD is using the National Computer Centre's (NCC) package course for systems analysts which runs for eight weeks in all and concludes with an examination. The ratio of trainees to staff on the course must not exceed 15:3. The present demand is for 300/400 places a year and MS(T) Division CSD, which can at present run only one or two streams (increasing to three streams by 1971), is therefore supplementing internal training courses with courses at NDPS and technical colleges. There is concern about the standard of the training provided by technical colleges and CSD is to sponsor courses run on its behalf by the City University. MS(T) Division CSD will consider reducing the length of the NCC course or of varying the length of the two stages (at present two weeks and six weeks respectively) in the light of experience.

(c) *Advanced systems designer*. MS(T) Division CSD intends to make use of courses provided by consultants, and possibly by other commercial concerns with ADP training establishments, and will appraise the suitability of NCC package and other courses in particular subjects (eg on-line systems; communications (eg networks; terminals); advanced hardware and software) as they become available. It may also develop its own courses, possibly in conjunction with NPL. Initially, external lecturers may be required to make up for the inexperience of Service instructors. Finally, a bursary scheme is being introduced under which selected Civil Servants will be sent to university for either a three or four year first honours degree in computing science or a post-graduate degree.

(d) *Computer Centre Manager*. No formal training has so far been organised for this category, although the annual computer managers conference convened by MS(C) Division CSD has provided a useful forum for the exchange of experience and ideas. MS(T) Division CSD expects that this training will consist of a mixture of practical experience in existing installations and theoretical instruction (depending on the experience of the individual) in such subjects as documentation, operating systems, job scheduling, costing and general management. Discussions are taking place with a firm of consultants about the suitability of their residential courses.

(e) *Computer Project Manager*. At present there is no systematic training. When the project manager is a former systems designer or programmer he will have had the usual training provided for these staff. If he is assigned to the job from line management his preparation will have varied. Probably it will have included an ADP appreciation or pre-programming course, and possibly manufacturers' programming courses or some more advanced training. MS(T) Division CSD is planning to make use of external courses and conferences supplemented by internal seminars.

(f) *Operating staff (ie console operators; team leaders)*. There is at present no centrally organised course in Government though DHSS Newcastle have started training the operators for their third-generation machines in basic operating techniques with additional seminars in operating systems and software. The importance of this form of training for third-generation machines is now generally recognised and an inter-departmental working party is being set up to consider the subject.

(g) *Data preparation staff*. Much of this training is at present carried out at installations either by the operating department itself or by commercial concerns. The training is in two parts: instruction in keyboard manipulation and machine operations, and instruction in the production of work from the type of documents used by the department. Some use has been made of Government central typing schools to teach basic keyboard manipulation.

(h) *Appreciation courses*. At present these consist of:

- (i) Two day appreciation courses run by MS(T) Division for Officers ranging from EO to Assistant Secretary. There are about 30 courses a year each taking between 35 and 50 officers and the course includes some practical work in flow charting, programming and systems analysis and design.
- (ii) Management courses for Assistant Principals and above which include one to two days on computer appreciation (extending to simple programming and use of a computer terminal).
- (iii) Senior management courses at Sunningdale for Assistant Secretaries and above (and equivalent grades). There are three courses a year each of four days. At present they take the form of general appreciation courses. Consideration is being given to including practical work on programming and the use of a terminal.
- (iv) One day seminars for Permanent and Deputy Secretaries.

Training staff requirement

355 At the present time the ADP training unit, which forms part of MS(T) Division CSD, has a complement of nine SEOs of whom only four are in post. The head of the division estimates that if the ADP unit is adequately to meet the bulk of the future demand for training anticipated by departments it must

be expanded to 36 staff in 1970 and more than doubled in size to 87 staff by 1974.[12]

356 We have examined these staffing forecasts in detail with the head of MS(T) Division CSD and are generally in agreement with the basis on which they have been framed. The figures assume, for example, that the bulk of ADP training should be carried out within the Service and not by massive recourse to external establishments (such as the universities, technical colleges, consultants, computer manufacturers and other concerns with ADP training establishments). This would follow the practice of some of the most efficient users of computers outside Government. It would ensure that training at all levels would be oriented to Service conditions and requirements. In particular, it would help to foster the development of common operational and procedural standards, and methods of working, right across the Service. We have already stressed, in the context of integration, that standardisation of all kinds is vital to the efficiency of Government computing in the 1970s.

357 A margin on the complement, of the kind sought,[13] is in our view essential. Again it accords with sound commercial practice. Although the instructors will be experienced ADP practitioners brought in for spells of between two to three years from departmental ADP units and MS(C) Division CSD they will need some unitial training as instructors. Thereafter they must have some time in which to keep abreast of developments in a swiftly advancing technology if they are to do their job effectively. Furthermore, we consider that, if they had time, officers in the ADP training unit would be well placed to undertake the necessary task of developing common standards of performance for programmers and systems analysts.

358 While we endorse the broad basis on which MS(T) Division CSD has made its ADP staffing forecasts we cannot estimate the number of instructors required with any precision. For one thing the actual requirements of particular departments will vary from year to year, and they have not yet looked beyond 1970/71. However, we have argued earlier that the number of ADP specialists required by Government will continue to grow in the 1970s. There is no doubt that these specialists will need to be of high quality or that they will require training in depth in a growing range of complex subjects. Training on the job, supplemented by a limited range of theoretical training provided in part by the manufacturers, will no longer suffice. Appreciation training must also be extended and improved. All these factors will impose a massive demand on the ADP training unit and this could well require resources on the scale predicted if it is to be satisfied internally. As further corroboration, a training unit of the size forecast would not appear to be out of line with those provided in commercial and industrial concerns making extensive use of computers. One company, for example, employs about 1,000 staff on computers, and we are told that this company has 40 graduate staff engaged primarily on ADP training with some support from the operational computer divisions. These tutors give instruction to about 40 new entrant graduates each year. They run twelve intensive residential courses annually for systems analysts, some of

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[12] In addition less than 50 SEOs, HEOs and EOs are engaged either full time or part time on training in departments. This number is not expected to increase significantly in future.

[13] This margin is claimed for marking papers, revising and updating courses in the light of technical developments and some research work.

whom are from other concerns, and also conduct familiarisation training courses for management.

359 We strongly recommend, for the reasons advanced in paragraph 356, that the ADP training unit should be built up as quickly as possible with the object of satisfying internally the greater part of Government's forecasted training requirements for the mid-1970s. If this course is adopted we do not believe there is any risk of producing a surplus of instructors. In this way the Government would play an important part as the biggest single employer of ADP staff in the UK in helping to overcome what could be a serious national deficiency in systems designers and programmers. This function of Government has, we understand, been endorsed in the past in other contexts.

360 This policy would not mean that no further use would be made of external training resources. The proper approach is a flexible one, in which external training is used to supplement Service efforts, for example where instructors of the appropriate calibre or expertise are unavailable or where external courses are superior to anything which could be mounted within the Service. As a general rule this situation will arise mainly with the advanced courses for more experienced staff.

General proposals for further improvement

361 As we have already acknowledged, active measures are continually being taken by MS(T) Division CSD and by departments to improve the quality and range of training for ADP staff. Great effort is being made to achieve a proper balance between on-the-job instruction, in-Service training, and external courses – the quality of which is continually being evaluated. It is against this background of progress, and in the expectation that at least some of our ideas will already have been implemented, that we make the suggestions in paragraphs 362 to 369.

362 As an essential preliminary to the development of satisfactory training programmes a detailed analysis needs to be made of the appropriate training for clearly defined categories of staff, taking account of their earlier training, experience, the work upon which they are engaged and their potential for further advancement. For example, there appears at the present time to be confusion in departments about the function of advanced systems designers. Until the position is clarified it will be difficult to devise suitable forms of training for these specialists.

363 When this analysis has been made training (certainly of systems designers and programmers) should, as far as is practicable, be tailored to suit the varying needs of staff. Training programmes should therefore be devised in modular form extending from the basic to the advanced level and only those parts taken which will advance the trainees' knowledge. This arrangement could save time and training resources.

Specific proposals

364 *Programmer:* The prime need appears to be for additional (in some instances advanced) instruction for senior programmers in such subjects as operating systems, new or specialised programming languages and the use of standard packages. Some of the courses would have particular value for

bureau programmers. All programmer courses should cover the need for standard documentation.

365 *Computer centre manager and operating staff:* The importance which companies with extensive computing experience are attaching to the calibre and training of their operating staff suggests that the training of operating staff generally in the Service, and of centre managers in particular needs to be developed. The efforts of NDPS (whose practical and theoretical training course may extend over one year) might usefully be examined. Manufacturers should be encouraged to provide more courses of instruction in their operating systems so that operators acquire the understanding which is essential if the full potential of the computer is to be exploited.

366 *Computer project manager:* Special training courses may have to be developed, possibly on the lines followed by commercial concerns, particularly for officers in line management with limited experience of computers who are given overall responsibility for computer based projects. The most important requirement is that departments should select in the near future the officers who will lead the major projects in the 1970s so that they can be groomed (by a mixture of practical training and courses) for the roles they will undertake.

367 *Data preparation staff:* Consideration should be given to the provision of more keyboard training for data preparation staff at Government typing schools. If the demand exceeds the places which these schools can offer there may be a case for establishing a central data preparation school.

368 *Appreciation courses:* There is general acceptance that this form of training for staff at all levels needs to be improved. The present range of courses should be reviewed systematically to produce a coherent form of appreciation training which is specifically related to the involvement of particular groups of officers with computers. The revised courses should be:

(a) more intensive than some of those currently provided (eg for senior management) and include practical work on systems design and the use of terminals (like for example, the six day residential courses run by IBM Ltd and other firms);

(b) more specifically related to what the computer can achieve as an integral part of the Government machine and be less a general exposition on computers. Some commercial concerns with extensive computing experience take the view that, to be effective, courses of this kind must give those attending a clear idea of the role of the computer in the context of their particular organisation. Their courses are therefore run jointly by senior management and senior ADP staff;

(c) regularly reviewed to take full account of the trends in general education and the increasing familiarity of young staff with computer concepts.

369 *Refresher courses:* There is a general demand in departments for refresher courses for experienced ADP specialists to bring them abreast of the latest developments in particular subjects. The subject matter for such courses needs to be considered in depth and they should be introduced as instructors become available. This is probably a field in which external lecturers could be used to advantage. The dissemination of technical information by MS(C) Division CSD – either in newsletters or technical booklets – will help to keep practitioners informed.

The implications of ADP developments for staff generally

Staff savings

370 As we have already remarked, a large number of the big clerical processes in Government have now been computerised, or are in the process of being converted to ADP. Thus many departments now have computer systems for such general functions as payroll, statistics and, in the case of MOD, for stores and stock control. Others use computers for particular departmental purposes – eg MAFF, DHSS, IR. Substantial savings in staff have either been achieved or are in prospect from these applications.

371 In addition, a number of departments are now working actively on projects which could either avoid the need for more staff or achieve further significant staff savings in the 1970s. The computer system for the DHSS earnings related scheme at Newcastle-upon-Tyne will serve in place of between 5,000 and 6,000 additional staff who would otherwise have been required to operate the scheme. In the Inland Revenue the computerising of some aspects of Schedule D, corporation tax, surtax and collection work is estimated to save about 2,500 staff in addition to the 5,000–6,000 who should have been saved when the PAYE system has been fully assumed by computers. Big savings should also be achieved in the Department of National Savings when POSB accounts have been converted; supplemented by a smaller saving if SAYE records are subsequently computerised.

372 With many of these projects the main staff savings are and will continue to be found among the clerical grades; there is in fact frequently an increase in the number of higher level executive staff employed. In some cases the problems of transition from a manual to a computer based system can give rise to a temporary but substantial increase in the staff numbers. For example, the computerising of PAYE, which involves the centralisation in a few large offices of tax payers' records previously held in the local tax districts, will require the temporary support of several hundred additional executive and clerical staff.

373 We are unable to forecast the scale of the staff changes which might result from the more speculative and longer term developments to which we referred in Chapters Three and Four, though the Civil Service Personnel Record and Information System is estimated to save about 600 staff. Further stores applications in both MOD and MPBW would probably achieve further savings among Service, clerical and industrial personnel. In the Lord Chancellor's Departments major schemes in the County Courts, Land Registry and Public Trustee Office could produce substantial savings; as might a computer based system for premium bonds in the Department of National Savings. Potentially there is scope for extensive staff savings in the computerising of higher level case work, filing and registry tasks and, to a lesser extent, accounting. But, as we have indicated, a great deal of research and development must be successfully concluded before extensive applications become practical possibilities, at least in the first two of these categories.

374 In the ADP field itself the development of Optical Character Recog-

nition holds out prospects for a reduction in the number of staff. This would affect only those employed on data preparation.

Consultation

375 Because of the fears which computers raise among staff who do not work directly with them it is essential, in our view, that there should be close and regular consultation between senior officers from the Official Side, and the Staff Side, at whatever level of representation (eg national or departmental) is appropriate, from an early stage in the development of any project which is likely to have a general impact upon staff. If the senior officials of the Staff Side are kept informed in this way they might well be able to scotch unfounded and alarmist rumours, even when it would be premature for the Official Side to make a formal statement to staff generally. Close contact from an early stage should certainly ensure that the necessary measures are taken in good time to avoid redundancy and to retrain and possibly redeploy staff whose work is affected with the minimum inconvenience to those concerned.

376 The need for effective consultation is already recognised by a majority of the departments with extensive computer applications. They keep officials of the staff associations fully abreast of developments, and the staff generally informed of what affects them by newsletter and at meetings. The National Staff Side told us that they in general are satisfied with the communication between the two Side on ADP matters; and the Official Sides in the departments have acknowledged the invaluable cooperation which they have had from their staff in implementing important projects.

377 We must record, however, that in a few of the departments we visited the Staff Side representatives told us that they were concerned by the lack of consultation over ADP projects which affected their members. The main burden of complaint was that the representatives themselves were not kept in the picture on ADP developments, and there was no regular flow of information to the staff even when schemes reached an advanced stage. In all these departments the Staff Side said they were given information only when they asked for it; and their Official Side contacts were either with relatively junior officers in the ADP unit or with someone in establishments division who could not speak with authority on computer matters. There is clearly a need in these places to improve the procedures for consultation.

7 Organising for the future

378 In this Chapter we review the functions and organisation of MS(C) Division, CSD, which is responsible for promoting the use of computers in central Government, and of those divisions in other departments which are concerned in some way with the provision of equipment for the actual user. We concentrate on Mintech's Systems and Automation Division (SA) and Technical Support Unit (TSU) but consider also HMSO (Computer Services) Division. Secondly we look at the organisation of ADP units within other computer-using departments.

Organisation at the centre

FUNCTIONS

379 In discharge of its responsibility for the coordination and central planning of administrative and general purpose data processing systems in Government, MS(C) Division, CSD has been associated at every stage with the design and implementation of all such systems. Officers from the division have been assigned in direct support of departmental planning teams and it has given advice on particular problem areas. With the supply divisions of the Treasury, MS(C) Division CSD has played a central role in the authorisation of administrative projects, and it has advised departments on the choice of equipment for both administrative and scientific computing. Advice on computer engineering problems has been obtained for departments through the division from the Technical Support Unit (TSU). TSU has hitherto been staffed mainly by Post Office engineers. Until early 1965 this unit was within the Treasury: it was then taken over by Mintech. MS(C) Division CSD has also undertaken a number of more general administrative functions in exercise of its central, coordinating role. It has, for example, helped to develop standard methods of processing and costing procedures, advised generally on computer policy and planning in Government, acted as a focal point for the exchange of views and ideas on computing both within Government and with other countries, and taken a particular interest in ADP staffing matters.

380 Mintech is responsible both for sponsoring the computer industry and for promoting the use of computers in the public and private sectors. In the latter respect it stands in broadly the same relationship to the remainder of the public sector (eg local authorities; NHS, nationalised industries; universities) as does MS(C) Division to central Government departments. But the TSU, working through MS(C) Division CSD, provides technical appraisals of

ADP equipment and systems, and advice on computer engineering, for central Government. It also carries out factory and site trials on computer equipment purchased on behalf of operating departments by HMSO. Since it became part of Mintech in 1965, TSU's services have not been confined to central Government.

381 In addition to its sponsorship, consulting and advisory functions Mintech is a major user of computers for scientific purposes, and has some administrative applications.

382 All computers for central Government with which we are concerned are bought through HMSO. The great majority of the computers used for administrative functions are bought on 'Allied Service' terms. Where computers are intended for research and development functions for which there is specific departmental Vote provision, the cost to HMSO is reimbursed by the departments. HMSO also negotiates contracts for the hire of computers, and for their maintenance. It purchases such stores as magnetic tape, punched cards and computer stationery. In addition it purchases computers for the universities on behalf of the Computer Board of DES.

383 HMSO is also a user: it operates the Central Computer Bureau at Norwich on behalf of customer departments. But it has no technical advisory role in so far as ADP systems are concerned.

384 The central arrangements for advising on and coordinating the development of computers in Government grew up in large measure on a fairly *ad hoc* basis in response to demand as computers were acquired by an increasing number of departments. On the whole they may be said to have served their purpose reasonably well, though they have had to be regularly reviewed to avoid duplication of effort and to ensure generally that they are geared to current conditions.

385 Thus, in 1969, CSD and Mintech have redefined their respective functions and agreed that, subject to the primary responsibility of each operating department for its own data processing as an essential part of the way it organises its work, central responsibility for the promotion of administrative and general purpose data processing systems within central Government will rest solely with MS(C) Division, CSD. CSD are also to take the lead in the formation of a standing committee on which representatives of central and local Government can exchange views and information about data processing matters of common interest. All departments whose computer projects affect the work of local authorities are likely to be represented on the committee.

386 It has also been agreed that TSU should continue as part of Mintech for the next two years, at the end of which time its future and location will be reconsidered. In the meantime MS(C) Division CSD will continue to have direct access to TSU and a joint board of management is being formed under Mintech chairmanship to supervise the Unit's programme of work, monitor progress and advise generally on its development.

387 The responsibility of HMSO for the procurement of computers on behalf of Government departments is to continue. The advantage in this arrangement is that HMSO is experienced generally in contracts and procurement, and is responsible for computer stationery.

388 It seems to be implicit in the measures now being adopted that Govern-

ment computing, and consequently the central organisation for controlling this work, should continue to lie within the Government machine and not be delegated to a semi-independent agency. For the reasons given in Chapter Six (paragraphs 313 to 315) we regard this as entirely right. We also accept that the central responsibility for coordinating and promoting the development of administrative data processing should remain with CSD. Data processing is now closely linked with the functions of other CSD divisions including the other Management Services Divisions, Machinery of Government, Manpower and Pay Divisions. To create a separate 'computing' department to take on the present or proposed functions of MS(C) Division CSD, and possibly to operate computers on behalf of some departments, would in our view be an undesirable complication: it would impede communications and generally impair the service required by computer-using departments.

389 We endorse the measures so far adopted for improving the central arrangements. They recognise the need for defined areas of responsibility and clearly established points of contact and lines of communication. We recommend that, as they are implemented, the prime objective should be the efficiency of Government computing, and that anything which would divert resources from this key task should take second place. There will also be a responsibility on all central units, not always recognised in the past, to set their own priorities in order that limited manpower resources may be concentrated effectively on the most important tasks.

PROJECT AUTHORISATION AND COSTING

390 The process of appraising (or justifying) a project, and then purchasing the computer, creates problems for the effective development of ADP systems in departments. Briefly, the first stage is a preliminary study by the user department taking about six months. If a detailed study is then approved by the CSD Manpower Division acting on MS(C) Division's advice, the next stage, which normally occupies up to 18 months, is fact finding, the preparation of a job specification and the development of a model system. If the results appear to justify the expenditure, financial authority is given by the appropriate Treasury Supply division and the project moves successively through the stages of issuing the operational requirements to manufacturers, tendering, selection and ordering the equipment. The total time from the start of the preliminary study to the placing of the computer order generally takes between two and three years. Delivery and implementation of the new system are estimated to take between two and a half and four years. The total time required for bringing a new system into full operation is therefore put at between four and a half and seven years: some of the larger ADP projects in Government have in fact taken longer.

391 ADP projects are appraised by the discounted cash flow technique using a test discount rate of 8 per cent (now 10 per cent). They are normally required to show a substantial surplus. Cost is not the only criterion, however, and projects which do not show a positive present value may be approved if it can be shown that additional indirect savings or some operating advantage can be achieved which justify the cost.

Weaknesses

392 The main criticism of these arrangements by departments has been that:

(a) The whole procedure takes too long and involves an inordinate amount of paper work.

(b) MS(C) Division CSD and the Treasury have been preoccupied with clerical savings from the use of computers. This is reflected in the spurious precision which is attached to cost savings and a failure to assess some projects in a wider context – eg in terms of compatibility with other systems or as an essential (and perhaps 'unprofitable') part of a larger system which will yield significant benefits.

(c) Present methods for proving the suitability of hardware and software before final acceptance from the manufacturers are inadequate. Departments consider that, as in the USA, central Government should put greater effort into the development of benchmarks and test programs which should then be run competitively to prescribed standards by the manufacturers tendering for particular contracts.

Speeding up the processes

393 Unquestionably the present procedures are protracted. We have been told that what in Government takes three years to carry through can be achieved in 18 months elsewhere. On the other hand, we believe that the meticulous care with which projects have been assessed is one reason why Government has not experienced the failures with its early ADP systems that have been common in commerce and industry. However, the need to streamline procedures which were framed for a situation in which departments were novices in ADP is accepted in principle by MS(C) Division CSD. Proposals have been made, for example, for cutting out the costing of theoretical alternatives for entirely new applications which could not in practice be performed manually, and a detailed costing where a replacement computer is to do exactly the same work as its predecessor. Intelligent anticipation in the early stages of planning could also lead to considerable reductions in time. So too will an increasing understanding of ADP among the senior officials in departments. In the past time has frequently been lost through indecision, and lack of direction to the project teams from those responsible for overall policy.

394 We consider that the most significant saving in time can be achieved when a single tender action is adopted for the purchase of a computer, by consulting the manufacturer at the fact finding stage and forgoing the traditional procedure of designing a model system. Experience will minimise the risk involved; and we recommend that, with this in mind, the appraisal procedures should be critically re-examined for further short-cuts.

Revising the costing procedures

395 An inter-departmental working party has been reviewing the adequacy, in the present stage of ADP development in Government, of the hitherto approved methods for costing proposed ADP systems. Already in a number of cases the prime condition of a substantial positive present value has had to be waived, either because the existing system was verging on complete breakdown

or a new function of Government could not be introduced without a computer. One important point for consideration has therefore been the extent to which social cost benefit factors should be introduced into the cost studies, and the significance to be attached to these somewhat intangible benefits.

396 Many of the commercial concerns of which we have knowledge do not attempt to justify in detail the purchase of a computer before it is acquired, and they use the discounted cash flow (DCF) technique only to get a broad indication of possible pay-off. The cost of the computer is considered in relation to the gross expenses and turnover of the company: the justification process is therefore mainly an exercise in judgement and in part an act of faith in the potential of the computer. It is in fact a commonly held view that the full advantages of a computer and the range of its applications can only be determined after it has been installed. Once the computer has been installed, however, its use is reviewed regularly at a very high level to make sure that it is being effectively operated.

397 Decreasing importance is therefore being attached to traditional costing criteria for computers, based on the DCF technique. The greater significance of the wider and less easily quantifiable advantages to be derived from computer systems has been generally accepted, and attempts are being made to refine the present crude methods for measuring these intangible benefits.

398 We do not believe that, in Government (where there is seldom a profit element to impose an over-riding check and discipline on expenditure), it would be right to dispense with costing procedures which include an estimate of staff requirements and savings, though we recommend that strenuous efforts should be made to simplify the form in which staff figures are presented. We further accept that, if detailed costings have to be attempted, the DCF technique should continue to be used: it is a way of illustrating clearly how costs are incurred over time and it facilitates the comparison of one project with another if priorities have to be determined. We do not think that the recent increase in the test discount rate from 8 per cent to 10 per cent will adversely affect future ADP development in Government, provided that the preparation of cash costings is regarded only as an initial though important stage in justifying a computer application, to be supplemented whenever appropriate by broader criteria of cost effectiveness.

399 This will mean taking account of the need to improve the public service or to avoid administrative breakdown when considering the cash costing. For example, the possible relationship of a particular project to a wider and perhaps integrated range of projects could justify additional expenditure in order to achieve compatibility between installations.

400 This broader basis for appraising computer projects is already adopted to some extent. We recommend that, in order to establish it effectively:

(a) A special study in depth should be mounted at once by MS(C) Division CSD to consider how estimated cash values (which might not be any less realistic than the present estimates of staff saving) might be attributed to some of those items which are presently regarded as unquantifiable.

(b) Departments should be required to supplement their assessment of the wider benefits to be derived from a computer system with an indication in some depth of how they propose to achieve these benefits. This should be more a description of specific procedures than a mere statement of intent.

(c) Projects which are authorised on grounds other than a substantial positive present value should be effectively monitored once they are in operation to ensure as far as possible that the forecasted benefits are being achieved and the computer is being used to maximum effect. This should not rest mainly upon the preparation of annual profitability returns. On the commercial analogy it should, in our opinion, involve directly someone in the operating department at Deputy or Under Secretary level, depending on the cost and importance of the installation. Such projects should also have priority for post-implementation reviews undertaken by MS(C) Division CSD.

401 In future, project appraisal will become a more complex operation and, at least with the big projects, must directly involve very senior staff. Authorisation of projects is likely to depend less on cash costings than in the past; and if priorities have to be determined for important projects because of financial or manpower constraints the decision is not likely to rest, as is sometimes assumed, with MS(C) Division CSD or the ADP units in departments. Their responsibility will be to see that those taking the decision have a full appreciation of the cost and other benefits before them.

MANAGEMENT SERVICES (COMPUTERS) DIVISION CSD

402 MS(C) Division CSD has accepted that its relationship with computer operating departments must change. It would be inefficient and wasteful of scarce resources for it to continue to attempt to participate directly in a rapidly expanding number of projects, particularly when considerable ADP expertise has been built up in some operating departments. The division therefore intends to devolve some of its present responsibilities for giving general support upon those departments which have adequate resources to take them over. The division will continue to provide a full service for smaller departments which lack their own resources, and to be available generally for advice on the preparation of operational requirements, tender evaluation and other matters of this kind. It will retain initial control at least of systems which cross departmental boundaries or otherwise break new ground. In the place of these devolved functions MS(C) Division CSD proposes to provide advice on such subjects as advanced systems design, software, information retrieval and data transmission techniques. It will build up a highly specialised group of staff for this purpose. It will also be in a position to devote more resources to the coordinated planning of ADP developments across Government, the initiation of advanced applications and the development of standards.

403 The success of MS(C) Division, CSD, will depend very much on the quality and number of staff which it is able to assemble. Some progress has been made in obtaining specialists in advanced systems and techniques. But, at a rough estimate, the division expects that it will have to expand from just over 40 staff in July 1969 to about 100 by 1974 if it is satisfactorily to discharge its functions, even after devolution. For the reasons we developed in Chapter Six we would expect an expansion of this order: until it is achieved the division will have to limit its activities strictly to those essential tasks which it can execute effectively with the resources at its disposal.

404 We outline in paragraphs 405 to 416 some of the imporant functions which should in future be undertaken by the three groups of MS(C) Division CSD.

Management supply and projects group

405 The present procedures for the appraisal and procurement of computers require further examination in the light of the growing experience of operating departments. If possible they should be simplified and shortened. The scope for quantifying in a meaningful fashion the wider benefits to be derived from ADP requires special study.

406 This group should also be responsible for the annual profitability returns on ADP projects rendered by operating departments and, in connection with these, for the conduct of post-implementation appraisal reviews on selected installations. We have already suggested that priority should be given to those systems which are approved on grounds other than substantial cash savings.

407 The personnel section, possibly in conjunction with external organisations, should conduct detailed research into such matters as job definition, selection, remuneration and the career planning of ADP personnel so that, as a true specialist in these matters, it can advise other CSD divisions and the operating departments.

408 The efforts of assignment officers in the projects branch should be concentrated on helping departments which for one reason or another do not have adequate numbers of experienced ADP staff, and on other projects in which MS(C) Division CSD must participate because of their size, special features or general implications for Government. On some occasions assignment officers may be joined in projects by representatives from the systems and techniques group or other Divisions within Management Services CSD. This mode of working in project teams is likely to increase considerably.

Policy and planning group

409 The duties of this group will be extensive and the responsibilities upon it for the future success of ADP developments in Government very heavy. It will be required to provide the detailed information and the statistical evidence upon which the broad strategy of ADP in Government must in future be settled. It will consider in depth the developing scope for functional integration between departments, and where appropriate propose, and possibly participate in, inter-departmental studies in this field. To do its job effectively it must advise on the requirements of compatibility, and select carefully those areas of work in Government in which improved compatibility is of the highest priority. It must therefore play a critical part in the early stages of project appraisal. It must also be in close touch with the Machinery of Government Divisions in CSD, with CDSU in the Central Statistical Office, and particularly with the systems and techniques group, and act as an informed channel of communication between and adviser to them all. It must know what is going on in scientific computing in Government so that it can contribute to the efficient development of networks and the maximum use of all Government computers. Externally, the planning group must be closely associated

with the consultative machinery established with the local authorities and, possibly, the nationalised industries and other bodies.

410 The first job of the planning group should, we suggest, be to draw up a central planning document in the form of a statement of phased objectives and a list of priorities. An essential part of this will be a table of the replacement dates for all administrative computers in Government. Some of the work of the review team will provide a basis for this table. The table will help to pinpoint the subjects requiring immediate action. Upon this basis the planners can then develop in detail their short term plans for two or three years ahead; and their longer term projections in more general terms for five to ten years ahead. It will need to be a continuing process, with the programme regularly reviewed and updated as needs change and new ones emerge.

Systems and techniques group

411 The central organisation for the promotion of ADP in Government must benefit from bringing together in one group responsibility for technical development and specialist advice on all aspects of hardware and software. But we do not believe that these vital functions can be properly undertaken if the group is not to integrate with its proposed functions the engineering work on hardware, systems and software appraisal which is currently undertaken on its behalf by the Mintech TSU. It is in our view an unnatural separation which would not be accepted in a commercial organisation.

412 The systems and techniques group must maintain close working relations with the planning group in MS(C) Division CSD and with Mintech. This is necessary so that the probable requirements of departments can be forecast well in advance as a basis for research and development. Another important function of the branch will be to evaluate objectively the ideas and suggestions which are put forward from numerous sources for improving computing in Government and, in conjunction with the planning group of MS(C) Division CSD and the operating departments, actively to sponsor those which merit serious consideration. This will help to meet the criticism sometimes made that sound proposals have been rejected out of hand by ultra-conservative departments.

413 The group should also take responsibility within Government for the development of common standards for the interchange of data between ADP systems. This will include work on data elements and codes. In part the group will undertake the work itself: in some specialised areas (eg education) it will coordinate the efforts of other departments. It will certainly need to consider the work of Mintech on common language development and information exchange in the international field. It might help to promote general application of common standards in particular areas of work if, as codes are established, they are entered in a central register maintained by the development branch. Departments concerned with a new application would then consult the register and be expected, if a code has already been registered in a similar area of work, to adopt that code. As we have already indicated, this is the practice in Canada.

414 The work on standards should extend to documentation. Where standardisation is in an area not immediately related to computer operations

(eg standard terminology) the group should maintain a watching brief but not make the running. A separate CSD unit, not necessarily within MS(C) Division CSD, may have to be set up to undertake the more general tasks of standardisation. The main responsibility of the systems and techniques group would be to see that the work of this unit fits in with the timetable for computer developments and takes due account of ADP factors.

415 As we have suggested, the systems and techniques group should examine the prospects for information retrieval, in order to advise on particular areas of application to which priority should be given and to make sure that all the expertise available in Government on this subject is used to widest advantage. We recommend that it should keep under review the use and development of the language PL1; and should devise and propagate among departments detailed methods for generally appraising in different circumstances the benefits of the large computer and the computer network.

416 Finally, we consider that with Mintech the systems and techniques group should take the initiative in constructing bench-marks for use in equipment evaluation and in acceptance testing.

417 This will constitute a very large programme of vital work for the systems and techniques group. The group must therefore husband its limited resources so that it is not over-extended. It would be of great benefit in these circumstances if, in association with Mintech, the branch could deploy on certain aspects of Government data processing the highly skilled staff working on computer developments in research stations like NEL, NPL, and RRE. We further recommend that, where a particular department has unrivalled experience and expertise in a particular subject such as production control or computer aided design, it should be nominated by the systems and techniques group to undertake on its behalf fundamental research in that subject. We understand that this has already been done to some extent. The systems and techniques group should, as soon as possible, mount a general review to determine the full scope for delegation on these lines.

418 We consider that it would change the whole nature of the systems and techniques group, and possibly of MS(C) Division CSD, and divert it from its primary tasks, to expand it into a Government software house. From the experience of NCC and NDPS we judge that it would mean an increase of between 200 and 400 in its complement. At this stage, therefore, software development should remain primarily the responsibility of the operating departments, and it makes better sense to concentrate in the ways we have suggested in Chapter Six on improving the quality of the systems designers at their disposal within departments, and at the centre on particular problems. As we also suggest in Chapter Six, external support should in certain circumstances be provided by commercial software firms and it should be the responsibility of the systems and techniques group to organise this service. Whether or not it will in the longer term be advantageous to attach a central Government software unit to the Civil Service College is something which we cannot predict.

419 The need for MS(C) Division CSD to concentrate highly skilled resources from one or more groups where they are most urgently required, and not to dissipate effort by attempting too much, cannot be overstressed. Projects on the scale and complexity of the police records (Home Office), short term benefits

(DHSS) and vehicle licensing (MOT) should have maximum support in whatever form may be necessary. The need is greatest where, as with the BSO project (BOT), there is no possibility of extended parallel running between the computer-based system and its predecessor.

Organisation of ADP in computer operating departments

Present arrangements

420 Inasmuch as individual departments have ultimate responsibility for the design, implementation and operation of their departmental ADP projects, their internal organisation of this work is very important. The methods for the control and development of ADP systems in central Government departments are, however, characterised by an astonishing variety and are only just beginning to respond to the recommendation in the Report of the Committee on the Civil Service that each major department should contain a management services unit.[1] It is impossible without outlining the organisation in 15 to 20 departments to give anything but a general impression of the present arrangements.

421 In the main the evolution of ADP out of departmental O & M branches is reflected in the existence of central ADP units with an essentially advisory function. In some cases this unit may retain some connection with O & M, if only in that both are located within departmental establishments divisions. In others there is no formal link between the two and the ADP unit may not in fact form part of the establishments division. In at least one department – DES – the ADP unit is within a planning branch headed jointly by the Principal Establishment Officer and the Director of Statistics. Special arrangements are necessary where, as in the case of HMSO and Mintech, the department has central functions concerning computers as well as its domestic installations.

422 We have observed three major weaknesses in the present arrangements though they are not, or all are not, found in every department. These are:

(a) The separation of ADP units from other management services appears to inhibit the formation of joint project teams made up, for example, of ADP and O & M specialists and, in some departments, staff trained in the techniques of operational research.

(b) The central ADP unit is unable adequately to discharge its functions of coordinating, directing and planning ADP developments within the department. In some cases this is partly a question of the small size of the unit and the low grading of the senior posts. We have pointed out that no operating department can spare senior staff for strategic planning: in some this deficiency is compounded by putting the central ADP unit in the charge of a relatively junior officer. But the main reason, and this is true of some major computer users, is that the real power and authority rests with separate ADP units in particular parts of a department to which the detailed work of developing and implementing particular projects has been delegated. In these cases it appears to be impossible for the central ADP unit to exercise effective control in order to ensure that developments are properly integrated and make the most effective use of resources. There are only a few exceptions, where the central ADP unit either carries full executive responsibility or assumes this for some major projects while leaving the remainder to particular branches.

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[1] Cmnd 3638, paragraphs 163–171.

(c) In surprisingly few departments do there appear to be adequate arrangements for regular contact between the ADP specialists and staff at Under Secretary level or above who are concerned with the general direction and policy of the department. In some departments we were told that there is no regular point of contact above Assistant Secretary level: in others, while there is formal machinery for considering ADP developments in a departmental context at Under Secretary level, it appears to be used fitfully. But some ADP units considered that, even without formal lines of communication, they could make known their views to policy makers in time for these to influence events. Most felt that things were slowly getting better.

Future developments

423 A review team has been formed within CSD to review in depth management services in the Civil Service.[2] It would therefore be premature for us to make detailed recommendations out of general context on the appropriate organisation for ADP units in departments. We hope, however, that the case will be firmly established for including the central ADP unit in a Management Services Division whose effective authority will extend across the whole department. A start on these lines has already been made in some departments, for example MOD. If organisations on these lines are given the staff they need to do their work effectively they will provide a sound framework for the planning and development of ADP in Government.

424 Whatever the precise organisation for departmental ADP in future we consider it essential that provision should be made for regular contact between ADP specialists and senior officers, who should increasingly be aware of the capacity and limitations of computers and, as we have recommended, take direct responsibility for the effective use of these machines. Some departments are already showing the way. For example:

(a) The Home Office (with the Metropolitan Police) has for some time had an ADP control structure which directly involves the Permanent Secretary. The General Purposes Sub-Committee chaired by an Under Secretary is the main working level. This meets at least every six weeks and is attended by computer users (or potential users) in the policy divisions and by finance and establishment officers.

(b) In a number of departments, including Inland Revenue and Ministry of Transport, direct overall responsibility for important ADP projects has been given a senior officer at Under Secretary level, who is also directly involved with associated policy matters including legislation.

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[2] Its terms of reference are: To consider, in the light of the recommendations made in the Fulton Report and the needs of management in the Civil Service, what provision should be made for Management Services in the Civil Service; to review the functions and organisation of management service units; and to make recommendations.

425 We recommend that measures of this sort for controlling ADP developments and integrating them effectively with the main stream of departmental work should be carefully considered for wider application.

8 Summary of findings and main recommendations

426 In this Chapter we summarise our main findings and more important recommendations. Each should be read in the light of the fuller explanation given earlier in the report. We follow the sequence of the report but, having regard to our terms of reference, find it useful occasionally to bring together matters treated separately.

Appraisal of the past

427 In general terms the early development of ADP in central Government has conformed to that outside Government and compares reasonably with it. It has been characterised by the predominance of the individual department, the wide spread of applications and the variety of equipment.

428 Equipment has been generally well suited to particular tasks at the time it was acquired (paragraph 48). The bulk of ADP and scientific computing work in Government is carried out on the computers of the departments providing the work. For a number of reasons this marked degree of dedication seems likely to continue (paragraphs 24 and 25).

429 In the early stages little regard was paid to compatibility. At the present time there are 30 different series of computers in use or on order for Government (paragraph 50). The resultant incompatibility is perhaps the most serious deficiency in Government's computer equipment. It may well restrict the pace and scope of future ADP development. It also increases costs (paragraph 52). In the last few years the position has been improved by the increasing reliance of departments on the ICL 1900 series (paragraph 53). We endorse the present policy of considering the need for compatibility at the time when ADP projects are authorised (paragraph 200).

430 Government may be slipping from its early place among the leaders in ADP, and there is cause for concern in the time taken to approve and then to implement new projects (paragraph 36). There is further cause for concern in that departments coming late to ADP may make the same mistakes as did the pioneers within and outside Government (paragraphs 43 and 44).

431 The absence of formal arrangements for the post-implementation review of ADP installations makes it difficult thoroughly to appraise applications and equipment and assess profitability and staff savings (paragraphs 32 and 40 to 42).

Plans

432 Plans already in existence are still predominantly departmental in character. As yet there is no coordinated planning of the development of ADP in central Government over the next decade. This is understandable. The growth of ADP has kept everybody at full stretch, with virtually no margins to spare for longer-term planning.

433 Up to the mid-1970s the replacement of equipment and the expansion of existing systems will make heavy demands on staff and account for a substantial part of the growth in Government ADP (paragraphs 29 and 30). Some departments consider that they must concentrate on these tasks, and consolidate before planning still more ambitious, longer-term projects (paragraph 103).

Future developments

Technological developments

434 Very large computers – or super computers – will become available during the 1970s, providing massive computer power at a continually reducing cost. It may be difficult for Government to exploit these to the full, at least in the shorter term (paragraphs 64 to 66). The development of the very large computers will be matched by the development of small, cheap and powerful computers, possibly linked with large ones (paragraphs 86 to 90 and 95), and there will be continued improvement in the middle-size range.

435 There will be developments in all aspects of computing, particularly in the latter part of the 1970s. Peripheral equipment will become cheaper and more efficient. Inefficiencies in data preparation will be reduced, storage devices will have much greater capacity and better performance and the speed and quality of printers will be improved. Data transmission facilities will be developed at a reducing cost and, with remote terminals, will facilitate the setting up of networks as the need for these is established (paragraphs 72 to 85 and 91 to 95).

436 There will be improvement in operating and other software, including more effective high-level languages and application packages. But some authorities, including certain manufacturers, consider that it will be up to ten years before operating software is developed to exploit fully the potential of the very large computers, and particularly to control complex multi-access systems (paragraphs 67 to 71 and 185).

Future applications

437 There are a number of large projects in prospect, for example in the fields of statistics, vehicle and driver licensing, Government personnel and crime (paragraphs 107 to 113, 219 to 222, and 245(e)). There are other longer-term possibilities, some concerning particular departments (paragraphs 114 to 131), and other functions affecting many departments – eg accounting; decision making; case work; information retrieval; computer-aided instruction and design (132 to 148).

438 There will probably be a significant growth in multi-access computing and bureau-type working in Government during the decade. At first, developments in multi-access systems will probably take place within the bigger departments with extensive computer requirements. We cannot predict the nature and extent of these developments. Multi-access systems will have to be carefully planned and costed in the light of closely defined objectives, and the formation of further bureaux must be preceded by intensive research into probable demand. Central planning will be essential to ensure that networks are developed efficiently (paragraphs 150 to 160).

439 There is and will continue to be a strong interdependence between technological developments and computer applications. There must be close contact between those planning future ADP developments in Government and the manufacturers so that equipment of the right sort will be available when required (paragraphs 98 to 101 and 412).

Integration

440 There are two broad categories of integration involving ADP – the exchange of data, which does not necessarily involve the integration of separate computer systems; and functional integration (paragraph 168).

441 The exchange of data is greatly facilitated where computers are compatible and there are common standards of various kinds. Generally, problems of compatibility and standardisation must be resolved before any substantial integration involving computers takes place (paragraphs 180 to 183, 198, 200, 256 and Appendix 1).

442 The most encouraging trends are in the exchange of machine readable data between departments and with external organisations (paragraphs 169 to 179), but departments must coordinate their negotiations with external organisations on data transfer (paragraph 182(c)).

443 The integration of separate ADP systems within Government is at an early stage and is likely to develop slowly. The creation of a large and complex data base which can be accessed on demand by a number of users with different requirements presents serious organisational and technical problems (paragraph 185). There are, however, several portents of systems integration (paragraphs 187 to 190). In particular areas:

(a) *MOD:* There is considerable integration within functions within each Service and a growing trend towards integration between functions within each Service. There is little integration between Services and decisions on this will be taken on operational or policy grounds and not primarily for ADP reasons (paragraphs 192 to 201).

(b) *DHSS: IR:* Both departments will be fully extended, implementing schemes now planned, until the mid to late 1970s. No serious thought has so far been given to the integration of major systems either within the respective department or inter-departmentally (paragraphs 202 to 209).

(c) *Statistics:* Although statistics would appear to be a relatively straightforward subject for integration, progress generally is likely to be gradual except possibly as regards industrial statistics. The pace will be dictated in part by the complexity of the tasks and the limited staff resources. Developments will also be constrained by the decentralised form of the Statistical Service and the departmental nature of much of the work (paragraphs 210 to 230).

(d) *Management information systems:* The development of advanced and in some cases integrated MIS in Government has begun (paragraph 245). But progress is likely to be slow. Experience elsewhere suggests that it could take ten years or more to develop the more complex systems, and involve comparatively large numbers of staff including senior officials (paragraphs 235 to 243). We favour development on a small scale initially, under central coordination and direction. An opportunity arises when departments redesign their administrative general purpose data processing systems (paragraphs 248 and 249).

444 The integration of ADP systems must follow decisions in principle to integrate particular functions. Integration is not fostered by the merging of departments which carry out essentially different functions. The computer cannot lead and cannot achieve integration where there are strong organisational reasons for maintaining separate operational units. There is not likely to be one comprehensive plan for the integration of longer-term ADP developments in central Government (paragraphs 252 to 255).

445 Nevertheless, where functional integration is considered to be advantageous computers can help in the process. Those responsible for ADP planning, centrally and in departments, must therefore work actively to create conditions in which such integration can be effectively achieved. This work must begin now (paragraphs 256 to 260).

Quantification

446 The whole process of computing in Government is now moving forward at a rate which involves doubling investment and personnel every two or three years.

447 The average annual growth rate of computer power in Government departments has been approximately 50 per cent per annum over the past five years and may be expected to continue at this rate until about 1974. Thereafter the position is much less certain but the increase in power over the ten years to 1980 will certainly be more than ten and could be twenty-fold (paragraphs 271 to 275).

448 This massive increase in power will probably be reflected in a substantial increase in the number of large and very large computers acquired by Government (paragraph 280), and could represent a net cumulative investment in hardware of more than £200 million between 1969 and 1980 at 1969 prices (paragraphs 288 and 289).

Impact on staff

449 Departments claim to have saved net about 2,500 staff up to March 1968 from using computers, and that in all some 13,000 staff will be saved from systems now in operation or at an advanced state of planning. These figures must be treated with reserve and only as a broad indication of the order of staff saving made possible by ADP (paragraphs 42, 370 and 371).

450 Some of the more speculative and longer term developments which we have forecast may produce substantial staff savings (paragraph 373). Among ADP personnel, the development of Optical Character Recognition offers prospects for a staff reduction (ie in data preparation staff) (paragraph 374).

451 With many projects the main staff savings are among the clerical grades. The introduction of ADP frequently results in an increase in the number of higher level executive staff. Transitional problems may give rise to temporary but substantial increases in staff numbers (paragraph 372).

452 The need for close and regular consultation with the Staff Side from an early stage in the development of ADP projects is recognised by a majority of the departments with extensive computer applications. In a few departments there is a need for improved consultation (paragraphs 375 to 377).

Constraints

453 Up to now, the introduction of ADP into departments does not appear to have been seriously restricted by financial, manpower or organisational considerations. Manpower shortages have caused some delay in starting or in completing worthwhile projects (paragraph 57). The lack of effective co-ordinating machinery and central planning has not caused serious concern while departments have been concentrating on internal applications (paragraph 58). Generally, the central organisation for Government ADP has served its purpose well though it requires to be regularly reviewed (paragraph 384). The main constraints in future will be with personnel and with organisation. These are the critical areas in which improvements must be made urgently if satisfactory progress is to be maintained through the next ten years.

Personnel

454 Personnel problems are acute. The annual average growth rate of specialist ADP staff between 1965 and 1969 was 30 per cent. The forecast increase in systems designers and programmers is from about 2,200 in 1969 to about 3,200 in 1974, and there is no indication that numbers will drop in the more distant future though the rate of increase may slacken (paragraphs 297 to 304). To select and train specialist staff on this scale imposes a very heavy burden on computer-operating departments.

455 Personnel problems are exacerbated by high wastage, attributable at junior levels to inadequate pay and dissatisfaction with career prospects in Government ADP (paragraphs 305 to 310).

456 Personnel problems cannot be surmounted satisfactorily by handing over the whole or a large part of Government's ADP to external organisations (paragraphs 313 to 316).

457 Resources to undertake Government computing in the 1970s can be found internally from the present Executive Classes, increasingly reinforced by staff brought in from various specialisms. The highly skilled staff in Mintech research stations should be more generally deployed in support of advanced ADP applications (paragraphs 318 to 322, 337 and 417). Senior staff who have specialised in particular aspects of computing should be available to advise departments introducing advanced applications (paragraph 336).

458 If staff of sufficiently high calibre are to be attracted into ADP, and retained, immediate improvements must be made in the pay of junior ADP staff, and comprehensive measures adopted to provide an adequate career or part career within ADP. Unless these matters are tackled promptly the whole foundation of Government computing will be in jeopardy (paragraph 323).

459 We recommend immediate action on a number of proposals for satisfying these requirements. These proposals concern pay, career planning and the grading and deployment of ADP personnel, including operating staff. General standards of performance should also be established (paragraphs 324 to 339).

460 ADP careers should continue to rest on a departmental foundation though departmental links will not necessarily be permanent. Central guidance and coordination will be essential, particularly for the filling of senior ADP appointments (paragraph 343). The creation of a formal occupational group could impose an undesirable rigidity on this essentially flexible system (paragraphs 345 and 346).

Training

461 A recent review of ADP training arrangements by MS(Training) Division, CSD, has established a massive demand for improved course-training for all categories of specialist ADP staff. There is also a growing need for ADP appreciation courses for other staff. These demands will continue to grow as the number of ADP specialists increases and more Civil Servants need to become familiar with the capabilities of computers (paragraphs 352 to 354).

462 The greater part of this expanded and improved training should be carried out within Government. This will require a relatively very large increase in the staff of the ADP training unit, and in training facilities generally, over the next four to five years. Until this is achieved use will have to be made of external establishments but, as far as possible, these external courses should be supervised and controlled by MS(Training) Division (paragraphs 355 to 359). Thereafter, external training resources should be used to supplement in-Service training (paragraph 360).

463 We recommend a number of measures for further improving the quality and range of ADP training. The essential preliminary is a detailed analysis of the appropriate training for clearly defined categories of staff so that training can be tailored to meet their varying requirements (paragraphs 362 to 369).

Central Organisation

464 Effective central planning of administrative and general purpose data processing systems, and of scientific computing, in central Government – in concert with parallel developments in the rest of the public and in the private sector – is essential. Only in this way can duplication of effort be avoided and compatibility and standardisation ensured. Responsibility for coordinating and promoting the development of ADP should remain with MS(C) Division (paragraph 388).

465 The departments primarily concerned with the central arrangements for the provision and use of computers in Government recognise the need for defined areas of responsibility and clearly established lines of communications (paragraphs 385 to 389).

466 We endorse most of the arrangements being made except that, in our view, MS(C) Division should have immediate access within the division to specialists in hardware and software of the kind now located in the Technical Support Unit within Mintech (paragraph 411).

467 We recommend that, in implementing these improvements, the prime object should be the efficiency of Government computing and that resources should not be diverted from this key responsibility. Within Government the central units must concentrate their resources effectively on the most important tasks (paragraph 389). This will demand strong management.

468 Problems arise over the appraisal and authorisation of ADP projects. Existing arrangements create misunderstanding and cause delay (paragraphs 390 to 392).

469 We recommend that these processes should be thoroughly re-examined in the light of growing experience, and outline various ways in which the processes of authorisation, costing and procurement might be improved (paragraphs 393 to 401).

The role of MS(C) Division, CSD

470 We recommend that MS(C) Division should assume the following important tasks in addition to those to be undertaken in connection with the review of project appraisal and authorisation:

(a) The conduct of post-implementation reviews on selected installations (paragraphs 400(c) and 406).

(b) Research into personnel matters – eg selection, remuneration and career planning of ADP personnel (paragraphs 301, 333, and 407).

(c) Planning in depth of the broad strategy of future ADP development in Government (paragraphs 409 and 410). This should in part consist of expanding on and continually up-dating the work which we have begun. It should include work in connection with the development of networks (paragraphs 158 to 160), and the promotion of functional integration in so far as this involves computers (paragraphs 258 to 260).

(d) Development of common standards for the interchange of data between ADP systems and the coordination of the work of other departments in this area (paragraphs 413 and 414).

(e) Examination of the prospects for information retrieval in Government in order to advise on particular areas of application to which priority should be given (paragraphs 143 to 145 and 415).

471 We recommend further tasks for MS(C) Division (paragraphs 412 and 415 to 417).

Organisation in operating departments

472 Departments do not have staff available for longer-term ADP planning (paragraph 304). The methods for the control and development of ADP systems in departments are characterised by their variety (paragraphs 420 and 421). This contributes to defective organisation, and a strong case can be made for including the central ADP unit in a Management Services organisation whose effective authority extends across the whole department (paragraphs 422 and 423).

473 There should in future be regular contact between ADP specialists and senior staff, who should be fully aware of the capability of computers and take direct responsibility for their effective use (see paragraphs 400, 401 and 424). We recommend that measures adopted by some departments for controlling ADP developments and integrating them in the mainstream of departmental work should be considered for wider application (paragraphs 424 and 425).

APPENDIX 1 STANDARDS AND COMPATIBILITY

Definition

1 In the text of the report the terms standards, standardisation and compatibility are used frequently and need to be distinguished and explained. This is not easy to do because, in computer parlance, the terms are not precisely defined and are on occasion used synonymously. They are certainly closely linked. For example, the development and acceptance of certain standards can contribute to compatibility. On the other hand, a limited degree of compatibility can be achieved without establishing common standards.

2 (a) A *standard* is a thing recognised as a model for imitation. Once adopted it therefore contributes to uniformity, the development of common practices and, in some forms, the compatibility of computer systems.

(b) *Standardisation* is the adoption of a particular standard or set of standards.

(c) *Compatibility* in its computer context indicates the relationship which exists between two or more computer systems. This relationship depends on the number of features which the systems have in common. If these common features happen to have been accepted as standards then all other systems subscribing the same standards will be compatible to the same degree.

STANDARDS

3 (a) There is a wide range of different kinds of standards. Their development has significance, to a greater or lesser degree, for the effective use of computers in data processing. In the report standards are considered under two broad categories:

(i) Those which facilitate the interchange of data between different users (eg departments and external organisations); and the aggregation, in a variety of forms and for a number of purposes, of data produced by particular users primarily for their domestic purposes.

(ii) Those which facilitate programming and systems work, and thus contribute to the more efficient use of specialist staff.

This is not a wholly valid distinction. Standards grouped under both heads may help to bring about greater compatibility between different computer systems, which in itself makes for efficiency and economy.

(b) There is a third set of standards more directly related to the computer itself, and to peripheral or associated equipment, to which reference is made in the section of this Appendix on compatibility.

4 (a) Within the first category are included standards in:

- (i) Codes for the representation of characters (including symbols and numbers) in machine readable form.
- (ii) The form in which the coded information is organised on such media as paper tape and magnetic tape.
- (iii) The media for interchange including data transmission control procedures.
- (iv) Classifications of data – eg in geographical, industrial or social terms, or by categories of commodity. This relates to coding in that common codes can be developed for standard classification.
- (v) Terminology, which extends beyond standard terms directly concerned with the computer to terms in general use in particular application areas.

(b) The development of standards in all these ways is an essential precondition to the integration of computer systems. Not all the work on achieving these standards – eg in such matters as terminology and classification – is the prime concern of computer specialists. They should however be associated with this work to ensure that the essential requirements of the computer are satisfied in developing associated standards.

5 (a) Within the second category are included standards in:

- (i) Documentation of programs and systems design at all stages; and in flow-chart symbols.
- (ii) High level programming languages.
- (iii) Application program packages for pay and records; stock control; network analysis; linear programming etc.

(b) Standards of this kind would help to achieve the most efficient use of specialist ADP staff by cutting out the extra training effort at present needed to teach different practices and languages, by facilitating the interchange of programs of common interest, and by reducing the difficulties that can at present arise when new staff are required to amend or update systems documented in an unfamiliar form. They would eliminate much of the present duplication.

Difficulty in achieving standardisation

6 The adoption of standards in order to achieve the undoubted balance of advantage which they bring is a slow and difficult process. Standards must be achieved through general agreement; this inevitably takes time as many different parties (users, manufacturers, professional bodies etc) are involved. Compromises have to be reached which may result in less than maximum efficiency when the standard is applied. In some areas – that of higher level language is a good example – the adoption of more than one standard may well turn out to be the best compromise. Timing can also present a problem; standardise too early and development is inhibited, too late and the standard is soon outmoded.

Progress

7 (a) United Kingdom: Mintech and MS(C) Division, CSD, have been active in attempting to introduce standards, through the British Standards Institute. The standard for achieving data interchange on magnetic tape using seven tracks and a packing density of 200 bits per inch has been adopted. It is mandatory for each Government computer installation to have a tape deck capable of reading and writing this tape, or to have the capability of adding one. MOD has set up a Standard Language Authority to consider standard information formats; and work is being carried out by other departments into standard classifications.

(b) USA: Government action in the USA has been more concerted than in the UK. The passing of the Brooks Bill in the USA in October, 1965, which delegated specific responsibility to the National Bureau of Standards to develop computer standards (in the broadest sense) for use within government, is a noteworthy event. The NBS set up a separate body, the Centre for Computer Sciences and Technology, to carry out its responsibilities under the Act: several standards, including a code for information interchange (eg code for data representation; mode of recording information on tape), have since been adopted as Federal Information Processing Standards. The Centre liaises closely with USASI (USA Standards Institute) which has, for many years, been the voluntary national body associated with the formulation of both national and international standards (through the International Organisation for Standardisation in this field).

COMPATIBILITY

8 Compatibility must be considered in terms of the function to be served. The main categories are data interchange, program interchange and machine interchange.

Data interchange

9 (a) The interchange of data between computer systems can be effected directly through data transmission links; or indirectly through the medium of paper tape, punched cards, magnetic tape, and documents bearing characters or other symbols in machine readable, optical or magnetic form. The following requirements must always be met:

- (i) the receiving system must be capable of accepting the input in its physical form; and
- (ii) it must be able to recognise the code in which the data is recorded, and the way in which it is organised on the paper or magnetic tape or other storage media (ie format).

Various equipment is available to convert the physical input into the desired form. But this is expensive and adds an additional step to the interchange process.

(b) So far as data transmission is concerned the work of the GPO and the CCITT (International Consultative Committee on Telephony and Telegraphy) has led to substantial national and international agreement on the means for transmitting information over public switched network lines (though not over the higher speed private lines). The actual control of the information transmitted (ie indications for the commencement of a message, for the end of a message, for requests to repeat etc) has become the subject of a proposed set of new standards, the first of which is to be ratified shortly. At the present time, data transmission can be most effectively accomplished by the linkage of equipment and computers of the same series. Transmission between different equipments can be achieved, at a cost, by the provision of additional software and/or hardware. The additional hardware is sometimes provided in the form of small message processing computers.

(c) Reference has been made in paragraph 4(a) to existing standards for interchange; more are required to match advances in the storage media. Common standards are not essential, however, for the interchange of data. Where they do not exist the necessary translation can be achieved, at a cost of course, by software. The development of cheap, flexible, read only memories may minimise the problem of code conversion by enabling it to be carried out quickly by means of hardware. Interchange may also require the production of special conversion programs – eg to enable the operating system of the receiving computer to accept the incoming magnetic tape.

(d) The transfer of data directly between computer memories gives rise to a special control and coding problem as most computers work in two different codes: an external one for taking in and giving out data; and an internal one for carrying out computation, data manipulation etc. Efforts are at present being made to find a standard method whereby computers can exchange information in their internal codes without the need for recourse to internal/external code conversion processes. Not all computers employ the same internal code, or have the same internal architecture; but it seems likely that progress will be made towards efficient memory to memory transfers of data. Even so the transfer of data over long distances at speeds approaching the internal speed of the computer must still be conditioned by the availability of high capacity transmission lines at an economically acceptable cost.

Program interchange

10 (a) Compatibility between computer systems depends on:

- (i) the ability of the receiving system to accept and interpret the program in the required manner; and
- (ii) sufficient core store (memory) and peripheral equipment of the right type in the receiving system to meet the requirements of the program.

(b) The first requirement depends on the language in which the program is written.

(c) If written in the lowest level language – ie in assembly or even machine code – the program will be acceptable only to a similar machine, or, if the machine is one of a range, to that range of machines (eg ICL 1900 range, IBM 360 range). Even then the program may contain instructions which can be implemented only on a machine of the same size as the one on which it was originated, or one higher in the range (generally known as 'upward compatibility'). Machines lower in a range often have a restricted instruction repertoire; in some ranges the limitation is partially overcome by the provision of relatively slow software routines to simulate the instructions performed by hardware higher in the range, but in others the bar is absolute. Standardisation on one range of machines does not therefore automatically confer program compatibility.

(d) If written in a higher level language such as COBOL or FORTRAN the program may be acceptable to another machine having a compiler for those languages. The snag is that the high level languages are frequently amplified in order to capitalise on the advantages of particular machines. Furthermore, individual users frequently incorporate in high level languages 'escape routines' written in assembly code to enable them satisfactorily to overcome some level of the shortcomings of the higher level language. A compiler will only cope with a program written in a high level language where it recognises the particular modifications adopted. Frequently, therefore, the exchange of programs written in high level languages can only be achieved at the cost of extensive program rewriting.

(e) Where a program cannot easily be modified in order to become acceptable to the receiving system it may be possible to use one of three techniques; simulation, translation or emulation to effect a bridge between the program and the system. These techniques require either special software or hardware for the purpose. The techniques are, however, grossly inefficient both in running time and in equipment utilisation. Developments in 'read only' memory may improve the capability for emulation although cost may still be a significant factor. The use of these techniques is, in the main, confined to the transfer of work from one machine to another when an earlier machine is being replaced, and is discontinued as soon as the existing programs can be rewritten for the new machine.

(f) The second prime requirement for program interchange – a large enough core and sufficient peripherals – must be met if a program which is otherwise acceptable to the machine is to be executed and results produced. But it is not an absolute requirement. In some machine systems the absence of a large core store is compensated for by access to external backing storage on disc or drum: some re-structuring of the program has then to be undertaken and a penalty paid in terms of extended running time. If the appropriate peripherals are not available it is possible with some of the advanced operating systems to compensate by substituting other peripherals (say a magnetic disc unit for a line printer) which, to the program can be made to 'look like' the desired peripheral. No penalty is usually incurred. To conclude, it is probably true to say in most cases that 'upwards compatibility' within a particular manufacturer's range should ensure program interchange of both assembly and higher level language programs without modification, and in the most suitable form for execution. Application packages are common to the range so that work based on these can be freely interchanged; the use of a common operating system minimizes organisational difficulties associated with the transfer of work; and data interchange is facilitated.

Machine interchange

11 This level of compatibility extends beyond data and program interchange to include, in its most ambitious form, the ability to take over the entire work load of another system without reprogramming, without additional operating software, or additional hardware; and to carry it out in the same time with identical results. The two systems concerned must have:–

(i) a central processor unit of the same logical design and internal architecture;
(ii) a memory of the same size and architecture;
(iii) the same number and type of peripherals and control units; and
(iv) the same operating system, language compilers and application packages.

In practice this very high level of compatibility is seldom, if ever, achieved. Systems approaching this level are used for real time or other applications where 100 per cent insurance against machine failure is required, and cost is a secondary consideration.

Peripheral equipment

12 In addition to compatibility of the three main types outlined in paragraphs 8–11 peripheral equipment is, with a few exceptions, exchangeable between machines in the same series. This makes possible an improvement in the capabilities of a particular machine with a minimum of disruption and without a need to reprogram.

13 Some peripheral equipment manufacturers already produce equipment which can be 'interfaced', at a cost, to different series of computer systems. The recent ratification, after development work at NPL, of a British Standard Interface specification should, if adopted by most manufacturers, extend the degree of compatibility in this area and make for a greater freedom in the choice of peripheral equipment.

GENERAL CONCLUSIONS

14 The already extensive and still rapidly expanding use of computers for data processing in Government across a wide range of applications has revealed an urgent need for the development of common standards of various kinds. Not all of these are directly connected with computing: but they are, almost without exception, an essential precondition to the integration of departmental functions and to the widespread and most efficient use of data produced within Government. Standardisation, certainly of codes and formats for data interchange, should therefore be prosecuted vigorously.

15 Standards also contribute to compatibility. Full compatibility can be achieved at present only between machines in the same manufacturer's range. But more limited compatibility, facilitating the interchange of data, and the exchange of programs, is already more generally attainable though only, in some instances, at a cost in time and efficiency. Data interchange is in fact now possible between most machines in Government although some work may be required to bring codes and data formats into line. Together, standardisation and compatibility can increase the flexibility of ADP equipment and reduce the demands on specialist manpower and training requirements.

In certain circumstances, they give the user greater freedom in his choice of equipment and so make possible a more advantageous purchasing policy.

16 This particular point has already been taken by the US Government. One object of the Brooks Bill was to establish standards which, if adopted, would lead to compatibility across whole ranges of different manufacturers' equipment. This would in large measure make the ADP systems of the US Government independent of particular machines: it would therefore avoid a monopoly situation and encourage healthy competition among the various manufacturers. The policy of the British Government is somewhat different, but the widespread adoption of the British Standard Interface could be a first move towards compatibility between different ranges of equipment.

APPENDIX 2 TECHNOLOGICAL DEVELOPMENTS OVER THE NEXT TEN YEARS

1 The information in this Appendix was assembled by Mr. P. Hearson. It represents the collective views and opinions of a large number of experts, within Government and elsewhere in the computer industry and commerce. Some of the information was obtained from publications; in this connection we should like to acknowledge the contribution to our work derived from internal documents made available by Mr. Ingham from his company. Much of the information was obtained in the course of extensive discussions with specialists in particular aspects of computing. We acknowledge a particular debt to the specialists in Mintech, including the staff of the Technical Support Unit, and in MS(C) Division, Civil Service Department. Outside central Government we obtained invaluable help from the GPO, including the Long Range Studies Division; and the Programmes Analysis Unit of UKAEA/ Mintech.

Large Scale Integration (LSI)

The fourth generation

2 Each generation of computer has been identified by the technology employed in its logic circuits. Thus the first generation was distinguished by the thermionic valve, the second by the transistor, and the third by integrated circuits (a number of transistors and associated circuit components in one, transistor type, encapsulation). The complex demands made on computer logic are pushing to the limit the employment of integrated circuits on printed circuit boards. Further advance must come from a higher degree of integration and the fourth generation, expected in the next 2/3 years, will be characterised by its use of LSI.

3 LSI may be described as the incorporation of many devices (transistor, diode and resistor) on a single integrated circuit chip. The advantages claimed include substantial cost reductions, increased reliability, increased speed and decrease in size. Not all of these advantages have been fully realised, and many problems still remain to be overcome. Nevertheless development and research in this field is being undertaken at a pace which is regarded as fast even by computer development standards, so that it is not possible to be dogmatic about the future.

4 Cost is determined by design and production costs, and consumer demand. The designer is faced with the problem of reducing the number of external connections to the LSI chip in relation to the number of logic gates it carries

(logic partitioning problem); the fewer the external connections the greater the production savings and the greater the reliability. The problem is least difficult with highly ordered logic – eg registers, main signal highways and memory – which exhibit a repetitive pattern in their design. It is acute with the control and timing logic which has a wide variety of circuits and interconnections.

5 Production difficulties arise in connection with camera work, material purity, the need for stringent working conditions, and test requirements. The yield drops very rapidly with the number of circuits contained on a slice. A yield of 40 per cent can be achieved with 10 circuits; this drops to 10 per cent with 20 circuits and continues to drop with further circuit increases. Several methods are being employed to minimise rejects and increase yield. These include the 'discretionary wiring technique' pioneered by Texas Instruments. With this, the various circuits on the slice are left unconnected, each circuit is probe-tested to identify faulty elements, the results are passed with details of the required logic to a computer aided design system, and the computer produces a wiring scheme to achieve the desired result. The problems associated with this technique are the high cost of computer aided design for each chip, the limitations inherent in the computer programs and the algorithms which they employ, and the variability of the end product which, although of similar logic design, may exhibit different circuit loadings.

6 Consumer demand will depend very much on the logical complexity of the devices produced. Shift registers, adders, memories and other circuits of this nature are common to most computers and should help to boost demand, but the more complex devices which reflect the design of a particular computer will be in demand only from the manufacturer of that computer. Small demand, complexity and low yield could mean that these devices are produced only where cost is a secondary consideration (eg aerospace applications). One attempt to reduce the cost is by use of the 'master slice' technique whereby a chip is produced containing a variety of unconnected circuits. These are later connected to produce the desired end result. The problem of low yield still remains however and is exacerbated by the fact that the very variety of circuits on a chip raises the yield threshold below which the chip must be rejected.

7 Cost reductions have been predicted at the rate of an order of magnitude every five years. The reduction will come from the increasing number of circuits on a chip whilst the cost of the chip itself stays relatively constant. However, this reduction in cost will not have a dramatic effect on the cost of supplying and maintaining a computer installation (including software). It has been estimated that the use of LSI for the entire CPU circuits would result in a cost saving of only 7 per cent compared with current techniques.

Reliability

8 While much information remains to be gathered on reliability the elimination of the present mass of external connections must, given satisfactory metallisation techniques for intra chip circuit connection, lead to greatly increased reliability. Such experience as is available supports this view. Although not strictly a function of reliability the sensitivity of LSI devices to

overload, and the volatility of information stored within the circuits, are factors which must be taken into account when the use of LSI is contemplated.

Speed

9 As the limitation on speed is the speed of light the reduction in size associated with LSI leads to shorter circuit paths and, therefore, shorter switching times. Here again there are problems. Two main types of LSI device can be identified: bipolar with switching times at present in the range of 20–2ns (subnano-second times are expected), and MOS (Metal Oxide Silicon) with switching times in the region of 100–150 ns (and improving). The former are the most expensive to produce, have a relatively high power requirement and can become very hot (up to 100 watts power per square inch of silicon). They require elaborate cooling facilities. The latter, on the other hand, require far fewer production processes and are thus cheaper. They are smaller (as little as 20 per cent of area taken by bipolar devices), need little power and produce little heat, but they are slower. The future, economically, favours MOS devices except in the very high speed requirement.

Size

10 Size will undoubtedly decrease by an order of magnitude and more compared with existing integrated circuits depending on the number of circuits per chip. This high density does, however, give rise to heat problems. Furthermore, little advantage will accrue where manually operated controls are directly associated with the devices eg tape decks will not reduce appreciably in size so long as a human operator has to manipulate the equipment. Size reduction will be necessary in aerospace applications, in optical recognition devices, and in such instruments as telephone handsets if PCM conversion modules are to be incorporated at the terminal.

Areas of application

11 The real impact of LSI is expected not in the replacement of existing electronic circuitry but in its application to new areas. Its use in very high speed scratch pad memories is already becoming economic. It will be used in associative memories (both with, or without linkage to cores); for read only memories to store permanent routines and micro-programs and for taking over some of the computers' executive routines (such as interrupt handling) thus making the executive predominantly hardware and faster. The cellular approach, leading to arrays of similar type circuits, will be adopted in registers of all types (possibly with longer word lengths); in standard interfaces and peripherals (eg VDU character generators; optical recognition device electronics (using photo diodes etc)), and in the incorporation of redundant circuitry to facilitate autodiagnosis of faults and self-repair. It will also be used where compactness with high reliability are paramount requirements (eg aerospace), and where high parallel processing capacity is required such as in the array processor (the Iliac IV computer).

Summary

12 To sum up. Present computer logic requirements are pushing the current technology to its limits. There is a need for LSI which will be introduced gradually, first into associative memories, registers, high speed memories and peripheral devices, and later into the area of executive routines, microprograms and self-repair etc. Progress will probably be made in solving existing problems, but it seems clear that, where economy is an important factor, a breakeven point will be reached beyond which further integration cannot be justified. The straight substitution of LSI for current electronics will in any case have small effect on the total cost of an installation. The cost advantage will flow from the greater power provided. The main impact of LSI will be on computer system design. It will provide greater power through a problem oriented logic structure, through the extended use of hardware to take over software functions and through faster circuits themselves. This, in its turn, will lead to an increased demand for faster main memories, and more powerful input/output devices. LSI will give greater reliability partly because of its facilities for self-repair.

Large computers

Introduction

13 Developments in technology, especially solid state electronics, supported by an increasing demand for computational power in the scientific field, and a growing awareness of the potential benefits of centralised computer facilities in the ADP field, has led to the production of large computer systems and the promise of much larger, and much more powerful, systems to come.

14 The number of computer circuits in the first solid state logic machines was in the order of 20,000. Current large machines contain upwards of 100,000, and a complement of 500,000 to 1,000,000 circuits is predicted for the mid '70s. In the decade since 1958 logic circuits speeds have increased by a factor of 20. Performance has increased by a factor of 100 and the cost per unit of performance decreased by one of 20. In terms of Atlas power, systems of eight times this power will shortly be available. Systems of 20–30 times Atlas will be available in the early 70's and the possibility of a system having 250 times the power of Atlas is already under consideration. A specialised system for array processing, estimated to have a power of 4,000 Atlas, is currently under development at the University of Illinois.

Nature of developments

15 These increases in processing power are not entirely due to developments in hardware technology. Significant advances in machine system design have played an important part. Notable amongst these are: the use of hardware 'stacks' to facilitate efficient multiprogramming, including re-entrant programming; memory interleaving and the use of high speed buffer memories to take optimum advantage of the range of stores (both high speed and high capacity) now becoming available; instruction overlap to speed computation; the organisation of small (at present) memories on an associative basis. Division of labour between the main processor and associated specialist

smaller processors (for input/output, control of communications lines, file manipulation, and maintenance etc) has also been achieved to increase efficiency and make for some degree of parallel processing.

16 With the availability of cheaper electronics and the growing demands on software there has been a marked trend towards the hardware implementation of processes. This trend has been accompanied by a growing versatility in basic function. At least one machine will offer the facility to work in a number of different formats (eg four bit character, eight bit character, 48 bit binary word etc). Another is expected to offer the facility of concurrent working in different modes (eg binary, decimal, floating point etc), utilising several processors served by a mass store. Nevertheless complex software systems are still necessary to ensure the efficient utilisation of the large systems. Hardware implementation of certain processes should limit the growth in complexity: it will not, in the foreseeable future, eliminate software systems.

17 Another development, now established for Burroughs' equipment, is the use of a higher level language as the basic programming language of the machine, and the associated development of the hardware to make this an efficient process. Another promised development lies in the use of micro-operators, a form of primitive language resident in the high speed memory. This would be linked together in one computer cycle time in different combinations to provide individual instruction repertoires suited to a variety of different tasks.

Provision against failure

18 As larger and larger computers have been developed so, at the same time, has grown the fear of breakdown with the consequent loss of valuable data. The duplication of facilities from the input file to the whole processor is one safeguard, although the cost may be prohibitive and difficulties would still exist in the control of dual processors. Much effort is currently being devoted to the development of hardware and software, to minimise the risk of breakdown, and to facilitate rapid diagnosis and repair once a fault occurs. One notable development is the use of a separate small processor to monitor performance (including the log of intermittent faults), initiate regular diagnostic tests, and quickly localise faults when they arise. The development of self-repair facilities by the inclusion of redundant, LSI, circuitry in the processor will, it is hoped, add the facility of almost immediate recovery from failure situations.

Fundamental research into machine system design

19 The developments outlined above are expected to be incorporated in working installations during the early and mid 1970's. Further progress will depend on the production of economic LSI circuits, and on other fundamental research now being carried out into machine system design. The development of the basic language machine to implement the basic language – a language which recognises the structure of data (see software para 30) – is the most advanced of this fundamental research. This is being followed by the development of a machine to carry out a very high degree of parallel processing (estimated at 10^8 instructions per second) by maniplating data as early as possible at the input stage into a form suitable for this form of processing. If

successful this development will call for a fundamental retraining of programmers and systems analysts. Algorithms will have to be developed to convert programs written, essentially, as serial processes into parallel ones. Finally, work is proceeding on the specification of a symbol processor design to operate on symbols in place of numerals. This is aimed at the efficient manipulation, classification and communication of data. Development of the basic language and a complementary machine may make it available to users in the middle to the late 70's: the other two developments referred to, if proved, are not expected to make any significant impact until the early 1980's or even later.

Summary

20 The trend towards larger and more versatile machines, and the improvement in system/cost performance ratios, is expected to continue well into the 1970's. Developments towards the end of the decade and beyond must depend on fundamental machine system redesign of the kind now being considered as well as on the continued development of hardware technology.

21 The continuation of the current rate of improvement in the cost/performance ratio will depend on:

(a) the economies of LSI including the point of optimum integration;

(b) the major developments in machine system design;

(c) the economic and technical developments in immediate access and backing stores and high speed peripheral devices;

(d) the production of efficient software to complement items (a), (b) and (c) above;

(e) consumer demand for large systems. This will take account of cost and will be generated by:

1 application developments particularly those benefiting from the existence of a large data bank;

2 the development of data transmission facilities by the GPO including, possibly, a dedicated digital transmission network;

3 the availability of large computers to users elsewhere, with or without smaller computers of their own;

4 the development of cheap, relatively powerful peripheral processing equipment;

5 the administrative and organisational difficulties inherent in large, centralised computer based installations;

(f) the successful development of measures to limit system down time due to failure; and of measures to offer fail safe, and fail soft, capabilities.

Software

Current problems

22 Software has been oversold; production time and cost under-estimated, and performance over-estimated. This is particularly true of operating systems, especially packages for real time working. The promise of higher level languages has not been fulfilled. There are many different dialects and this

makes it very difficult to achieve compatibility between machine systems. The inefficiency of compilers and the object code they produce is a matter of continuing concern. Few computers provide the facilities necessary for full advantage to be taken of hardware developments. There is a growing need for higher level languages to be tailored to the problems of individual customers. There is a pressing need for the better documentation of programs, for a more effective organisation of software production by users, and for the testing of manufacturer-produced software before use.

23 These problems are recognised and much thought given to their solution, with some success. Nevertheless the growth in large and complex computer applications, and developments in hardware technology, have underlined the urgent need for complementary, efficient software.

Impact of hardware developments

24 Developments in hardware may well prove to be the most decisive factor in software development during the next 10 years and beyond. On the one hand these developments will create a demand for more complex software systems. The more powerful the computer and the wider the variety of application, the greater becomes the need for developed, reliable software. Larger and more easily accessible storage devices have a potential for information retrieval. Such devices, allied to the increasing power of the central processor, and the development of data communication facilities, require powerful and sophisticated software in order to produce effective, time-sharing systems. On the other hand hardware will undoubtedly assume some software functions and ease the software function in other areas. The development of mass immediate access stores of 4 Megabits and over, now well under way, will enable many large programs to be entirely resident in this level of storage. This will make for a significant increase in efficiency at no extra software cost. The further development of associative memories will simplify table lock-up and paging (where this is still necessary); and the availability of cheap, fast, read only storage will enable commonly used routines (eg tax calculation) to be carried out by hardware. Further development of this latter facility could well lead to the tailoring of machine code to specific applications and the more efficient implementation of higher level language programs. Flexibility would be achieved either by having the storage on a form of interchangeable card, or by using NDRO storage (with fast read, slow write) with potential speed advantages (by working at the clock rate of the machine instead of the cycle time of the main store).

25 The further development of flexible input/output processors, such as OCR readers, will open a new field for software in enabling data capture to be more efficient.

Higher level languages

26 The intention behind the higher level languages was the production of problem oriented, machine independent, languages which could be used by people without computer expertise for solving their problems. Higher level languages have in fact met a need in problem solving. Even in this field they have been found by a number of users to be insufficiently oriented to their

particular problems. Machine independence has been compromised by the development of dialects. Other advantages claimed for higher level languages include the quicker production and easier testing of programs. These have been obtained but the higher languages are less efficient than machine and assembly code and add to store usage and computer running time. Other disadvantages have arisen from the failure of the languages to keep pace with developments in systems design. COBOL, FORTRAN and ALGOL were all developed in the days when magnetic tape with its serial processing implications for systems design was dominant. They were therefore not powerful enough to meet the later demands of real time working or the full demands of direct access processing (none can handle variable length working on disc, and FORTRAN cannot handle access in the indexed sequential mode). To a limited extent escape into assembly code has been possible to meet the deficiencies in the higher level facilities. This facility in its turn further restricted machine independence.

27 Increasing sophistication in central processor logic, and much larger immediate access stores, have eliminated most of the gross inefficiency in the use of the computer store and running time. This trend is expected to continue. Indeed at least one American manufacturer, Burroughs, now offers a range of large machines which can be programmed only in higher level language: a high level of efficiency is claimed. New versions of the languages are gradually being introduced to remedy the lack of facilities revealed by system developments, ALGOL 68, for example, provides for direct access working as well as some features needed in commercial applications. Further developments include the provision of facilities for modular programming (USASI COBOL), and renewed attempts to achieve machine independence with the introduction of updated versions of the languages. Modular programming facilities may well be extended to most of the languages but the achievement of a higher degree of machine independence must be viewed with some scepticism.

Special purpose languages

28 Problem orientation is being intensified by the development of a number of new higher level languages. LISP has been developed for list processing; SPECOL for information retrieval; SIMON, SIMULA etc for simulation; APT for the numerical control of machine tools; TELCOMP and POP 2 for time sharing etc etc. This trend is expected to continue with the refinement of existing languages and the development of others as the need arises.

PLI

29 The introduction of PLI, one language designed to cater for the needs of both commercial and scientific users, represents an opposite trend. It offers a number of advanced facilities, including the ability to handle variable length records on disc and teleprocessing type work, and to deal effectively with other forms of input/output. It is modular in construction. Although it is not offered as a replacement for existing higher level languages it is hoped that it will not be diversified into dialect form. It could be useful where mixed scientific/ADP type work has to be undertaken, and be easy to use and test. This language is currently the subject of much controversy, particularly with

scientific users. Some commercial users have found it useful in that it enables relatively inexperienced programmers to write useful programs in a minimum of time. On the debit side the store requirements of the object program are high, and care is needed in the statements used to avoid excessive running time. Much depends on IBM, the sponsor of the language, for its continued development and ultimate acceptance. Improvements have already been made.

Basic language

30 All the higher level languages, including PLI, so far mentioned have reflected Von Neumann's concept of the computer. This includes the concept of the linear store whereby data and instructions are located in the store by reference to location numbers. Refinements have been developed which enable some measure of the structure inherent in both data and processing instructions to be reflected in software, and in the hardware organisation of the machine. But, until recently, the prime concept has remained intact, with the consequential inefficiencies associated with fixed reference frame location. Research is now well advanced into the creation of a Basic Language based on a name structure, which reflects the natural structure in sets of data and instructions. The language is seen as the equivalent of the order code for conventional machines, and is the object code produced by higher level languages. The design of a computer to execute assembled basic language programs takes account of the structure of the information to be processed by the use of a system of codewords which define the number of instructions or data items in a set, and their position in store. The conceptual store thus approximates to a tree type structure and, by use of the codeword, provides for access to the actual store by hardware, to a greater extent than ever before achieved. Claims for the Basic Language Machine include the ability to tackle, economically, a wider range of problems than has hitherto been possible. It is also said to detect and correct program errors more effectively; to effect dynamic allocation of storage in a more efficient manner than is at present feasible and to develop advance coding techniques. An experimental machine has already been developed to implement the language, and as a result improvements have been made. Work is understood to be well advanced at Manchester University on the construction of a machine which reflects the concepts of Basic Language. The store is accessed by name utilising associative memory, and it is organised in segments with lock-out facilities. The machine is oriented to scientific type work and is expected to be 50 times the power of Atlas. The hardware is expected to cost £500,000.

Report program generators

31 This brief survey of higher level languages would not be complete without mention of the Report Generator type of package currently offered by a number of manufacturers, and by users who have developed their own versions. These packages offer, in a well structured form, a limited higher level language capability for use by people with little or no knowledge of computers. The user specifies his requirements, often limited to the computation of aggregated statistics and their production in table and graphic form, in a way which is both familiar to himself and, by virtue of the software package, acceptable

to the computer. Although originally severely limited these packages are now beginning to offer more extensive facilities and, in some commercial installations, are already regarded as the prime programming language. Noted among these packages is IBM's RPG for System 360 (versions are available for ICL's 1,900 and System 4 series); the Table Processing System offered by Mintech and the complementary Statistical Table Generator produced by D.E.S.; the NITA generator (which uses decision tables) offered by NCC; and COGENT, a package under development by consultants and believed to offer the most advanced facilities yet.

Operating systems

32 The development of larger computers with faster tape units and direct access storage devices; and their employment in multiprogramming, multiprocessing and time sharing modes, has put increasing demands on the operating requirements of the equipment. It has also placed correspondingly heavier penalties on inefficient operation. In an attempt to meet the situation computer manufacturers undertook the development of comprehensive operating systems to relieve the operator of the routine tasks and leave him free to devote his full attention to emergency conditions. The task was grossly underestimated, as were such problems as the complexities of scheduling, file opening and closing, segmentation, recovery provisions. As a result the provision of operating systems was delayed long beyond the scheduled dates, they performed indifferently and were subject to breakdown. Moreover they incurred heavy overheads on computer time and store usage. Another matter for concern has been over operating systems designed for multiprocessor control, where it has been found easier to operate in a slave/master relationship than in a situation of equality.

33 Lessons have been learned from these early attempts and reasonably efficient systems offering a wide range of facilities are beginning to emerge. Although store requirements are still high the relative decline of hardware costs in relation to staff costs has lessened pressures for improvement in this area. The pressing need is for skilled staff (several man years of effort per system is envisaged) to take a system, integrate it into the total operating environment of the installation and thus optimize its use in a dynamic situation.

34 There has been less success with the development of systems for handling time sharing, especially real-time, systems. There is growing trend away from a monolithic all embracing system for handling terminals, and all the other computer functions, to a system which splits its functions between a main central processor and a smaller pre-processor, or data concentrator. The latter is used to carry out the basic time sharing housekeeping including direct access to the computers backing store.

35 Future needs are for efficient, less generalised, operating systems tailored more nearly to the customers' requirements. This would increase operational efficiency and relieve overhead costs. This requirement is beginning to be met by at least one manufacturer who offers a selection of operating modules which can be combined into a basic operating system. There are already indications that this trend will develop. Fundamental research into the development of machine independent software is being carried out centred on the production

of tailored operating systems (and the writing of compilers). The work is based on a system of macros which offer extensive facilities to the operating designer for specifying his requirements, and are capable of being turned into efficient machine code. Associated with this work is the production of a simulator for testing in a real time environment the operating systems being developed, and the development of software monitor packages. The latter can be incorporated in systems in everyday use to give a measure of their performance. They will thus lead to further improvement. Work on all these areas is expected to show results within the next two years. Interest is also being shown in the development of a standard command language for use with operating systems, but progress to this end must, inevitably, take much longer.

36 Further attempts to improve the efficiency of software are being made. Work is in progress on the specification of software requirements in a comprehensive and precise manner using the list processing language LISP. If this can be done with sufficient degree of precision the development of a software generator is envisaged (one for each type of computer). This will take the LISP listing and produce tailor made software such as an operating system from it. This development holds out the possibility of automating software documentation, and the generation of test data. While it is not yet possible to say if this approach to the automated production of software will be successful it is clear that, if it is, fewer but more highly skilled programmers will be required.

37 Progress will also be made in the time sharing and multi-processor fields. This is a difficult area and it may be many years before all requirements are met. Hardware developments will probably play an important part in this area.

Definition of software

38 Work on the definition of software which would allow the function of program modules and their interfaces to be rigorously specified is also being carried out. The successful outcome of this would enable the advanced 'debugging' aids to be developed, as well as the comprehensive documentation of design decisions.

39 The need for effective intercommunication between computer users, and the elimination of costly duplication, continues to grow as the technology develops. Work such as that mentioned above, and at the NCC in establishing a program library – and international software conferences such as that recently held at Garmisch – suggests that progress will be made in this matter.

User development of software

40 The need for a better controlled approach to the production of user software, for example to accommodate varying degrees of skill in a programming team, has led to a revived interest in modular programming techniques. These techniques, in different forms and under different titles, were frequently used with first generation computers employing machine code. Their use became more difficult with the development of assembly and higher level languages, as the programmer no longer had direct control over the precise location of

data within the core store. It is only recently that an attempt has been made, by management consultants, to systematize the procedure and consolidate practice across the field. The various systems offered by the management consultants range from those relying solely on a strict discipline for defining modules, their interfaces and method of desk testing etc; to those providing extensive software for the live testing of modules etc. A number of concerns claim the techniques to be valuable. Although the total time required to develop a program tends to be longer, the elapsed time can be substantially reduced and program maintenance problems minimised.

41 Progress in this field has been retarded by lack of facilities in the software area. Higher level language compilers and operating systems have not, with some exceptions, provided for the independent testing of modules, the sharing of common files etc. The incorporation of these facilities in USASI COBOL, and some operating systems, are hopeful developments and more are expected.

42 Interest is also being shown in software performance measurement under working conditions. Both time and memory requirements are measured so that efficiency can be determined, and areas identified where improvements might be made. Some measuring aids (by Boole and Babbage) are already available but many more can be expected in the next few years.

Testing of manufacturers' software

43 The need is recognised to submit software to some form of testing, such as is at present given to hardware. This would establish its quality and confirm that what has been ordered has been supplied. The Technical Support Unit of the Ministry of Technology has recently put forward a scheme of type approval testing. It is hoped that this scheme will give users greater confidence in the software offered to them, and so enable implementation to proceed with greater speed and certainty.

Software pricing

44 IBM have announced a new policy of pricing software separately. The full implications of this policy have not yet been worked out. Much will depend on the extent to which other manufacturers adopt the same policy; the precise way in which they implement it; and the extent to which customers have a requirement for the 'freed' software. If widely adopted the policy could lead to greater flexibility, to the increased use of independent software houses, and the benefits of greater competition. On the other hand, total system and hardware costs could rise, duplication of work increase and problems of program compatibility grow.

Summary

45 The rapid and extensive development of computer hardware has led to the design of very large computer systems and made possible the execution of a wide range of complex tasks hitherto not considered to be practicable propositions. This has led to heavy demands on software which must be met if full advantage is to be taken of the potential power offered by the hardware. Although the hardware itself will undertake some of the functions previously

undertaken by software no limit can yet been seen to the growing demand for more efficient, and more complex, software.

46 High in priority is the need for efficient operating systems to control the many functions carried out by the large computer. Early attempts to produce all embracing systems resulted in some notable failures, but the early lessons appear to have been learnt and some success is beginning to attend less ambitious systems. The need to design systems in relation to a specific operating environment has been recognised and is being met, in part, by a modular approach. Current research is known to be concerned with the tailor-made approach to operating system design. Even so the development of systems to implement time-sharing and multiprocessor applications, is expected to present difficulty for years to come.

47 The gross inefficiency of early higher level languages, and their inability to match the potential offered by the latest hardware; are being met by the introduction of revised versions of these languages, by logic design tailored to their efficient implementation, and, as with operating systems, to the introduction and refinement of languages designed to deal with specific problems. Such inefficiency as remains is of diminishing significance due to the availability of more powerful computers, with much larger immediate access storage, at less cost; and to the complementary rise in staff costs. These languages have not yet fulfilled their promise of machine independence although PLI may, if supported by most manufacturers, eventually offer the greatest hope for such independence. Research is concerned with the introduction of facilities, such as modular programming, to enable programming effort to be used to the best effect; with the development of Basic Language, a language closely related to the structure of problems to be solved; and with the development of advanced RPG packages so that more extensive facilities may be offered to users without computer expertise.

48 Increasing interest is being shown in the type testing of manufacturers' software; in the precise definition of software so that unnecessary duplication of effort may be avoided; and in the use of measuring aids to determine the efficiency of user produced software. The recent move by IBM to charge separately for certain items of software may have significant effect on the pattern of software provision; but until the precise intentions of the other major manufacturers are known the significance of the move for Government cannot be predicted.

Peripherals – Magnetic tape

Main areas of development

49 Technical development of magnetic tape peripherals used for on-line backing store is in the main oriented towards further and significant exploitation of the information bit packing potential of the magnetic medium. Other developments will include mechanical design features aimed at minimising tape wear, and facilitating ease of operation.

Phase encoding recording technique

50 Present techniques based on the phase encoding recording technique provides for a packing density of 1,600 rows per inch on tape with 9 channels.

Work is progressing in several companies on a packing density of 3,200 rpi and there is little doubt that tape units capable of handling this density will be commercially available within the next 4/5 years. 5,000 rpi and even higher packing densities have been achieved under laboratory conditions but it is not known how far this work will be developed.

Analogue recording technique

51 The employment of non-saturation recording featured in the phase encoding technique is also being employed in the development of an analogue recording technique related to information theory. This technique permits a greater recording density; 10,000 rpi on 36 channel 1 inch tape has already been achieved, although electrical noise is a problem. Packing densities in the order of 30,000 rpi on 36 channel tape are envisaged within the next 2/3 years and it is considered that tape decks capable of handling this tape will be available commercially towards the end of the decade. Research is currently being undertaken into packing densities of 90,000 and 180,000 rpi but it is not yet possible to say what success will attend these efforts.

Transverse recording technique

52 Development is well advanced on another form of recording using 2 inch tape and the proven transverse recording technique developed and used for video applications. A small prototype model has been built by Ampex which provides for recording at a packing density of 700,000 bits to the square inch (current 9 track 1,600 rpi systems have a packing density of 28,800 bits/sq in); and extension to double this density is considered practicable. A tape search speed of 1,000 inches/second is claimed, and a data transfer rate of 6 M. bits per second. Various combinations of tape deck and controller are possible. With only two decks and one controller an on-line capacity of 10^{11} bits (equivalent to thirty IBM data cells) is available. This high capacity allied with the high search speed provides the equivalent performance of a direct access facility even though search is carried out in a sequential mode. A small core buffer, and either a small disc or drum are considered to be necessary to interface this equipment to the central processor because of the large data blocks concerned.

Mechanical design

53 Improvements in mechanical design are a consolidation of existing developments rather than fundamental changes. No improvement in tape passing speed is envisaged. The inertia associated with mechanical handling systems is considered to be the factor limiting further development. The use of a rubber covered single capstan already used on some decks is expected to become widespread. This arrangement reduces tape wear, has fewer parts and is more reliable than the majority of existing drive mechanisms. Tape cleaners will become an integral part of the deck and the facility of cartridge loading, already used with a few decks, is expected to gain in popularity. Both will reduce tape wear, and the latter will aid operator handling. The development of the 'cluster' tape unit by Burroughs, in which feed and take-up spools share a common spindle, common electronics and some common hardware is

the most radical design departure to date. Its main advantage appears to be cost reduction. But, there is doubt about its maintenance, and its high degree of commonality impairs the function of all four of the constituent drives when a fault occurs. Little future is seen for this development in Government installations.

Error correction systems

54 The fuller exploitation of tape packing density, and the employment of more advanced recording techniques, requires corresponding development in error correction systems. The use of integrated circuits and the introduction of LSI will help. The use of a deskewering buffer for each channel on 9 channel phase encoded tape is a current example of this development and provides for the correction of both electrical and mechanical skew.

Cheaper tape decks

55 The development of the technology required to produce decks with high transfer rates is also expected to lead, as a by-product, to the production of cheaper low transfer decks. High packing densities will be used with slow tape deck drive rates (18¾ inches per second).

Incremental tape units

56 The use of incremental magnetic tape units, already well known in the data logging field, will continue and speeds up to 1,000 steps per second are anticipated by the mid 1970's. Commercial applications are already making greater use of incremental tape units in data preparation, and this is expected to grow in popularity. Its use in Government installations is less certain. There are doubts about its economic viability in the majority of applications, and there will be an alternative facility in keyboards linked to a mass store via a small computer. Incremental magnetic tape units are already used as a form of high capacity low speed buffer at several message switching centres. They are expected to continue to figure in the design of data transmission systems.

57 Research and development of the magnetic tape itself will ensure that developments in recording equipment are not jeopardised by an inferior recording medium.

Summary

58 To sum up. Over the next ten years data transfer rates of at least an order of magnitude greater than current performance can be expected, and even higher rates are possible. Although firm costs are not yet known the cost of transferring data to and from magnetic tape is expected to decrease. The higher transfer rates will require larger buffer areas and are therefore likely to be available in the large systems configurations. Cheaper slow decks will become available for use with small computers, and there may be some increase in the use of incremental tape equipment. But the present trend towards the use of discs will continue. In association with cheap mass memories they will replace magnetic tape equipment as the main form of backing store during the late 1970's. Nevertheless, tape will continue to play an important role for archival

storage, as a dump medium from memory and direct access devices, and as main backing store in sequential systems with a high hit rate. As regards standardisation, there are two imponderables: the attitude of IBM, and the extent to which the British Standard Interface is adopted by manufacturers for use with slow tape units.

Peripherals – Discs, drums and magnetic cards

59 Discs and drums have many similarities and are reviewed together. But the disc offers a greater data packing potential for a given volume than the drum, although access to that data may take a longer time.

Bit density

60 Developments in this field are expected to be gradual, but worthwhile. Increases in packing density, both in the bit density per track, and the track density are anticipated. A bit density of 2,200 bits per inch is now available, and this could be doubled during the early 1970's. Further development is bound up with research into the magnetic recording medium. Two firms are already using metal recording surfaces for high packing densities. A bit density of 15,000 bits per inch has already been achieved in the laboratory using digital recording techniques but there are considerable problems in the wear of recording surfaces, and in the production of recording heads with very fine gaps. Analogue recording techniques offer the prospect of even greater bit densities but the practical achievement of these is probably ten years ahead.

Track density

61 Track densities of 100 tracks per inch are now available and double this density is expected in the early 1970's. A density of 300 tpi is regarded as a reasonable expectation by the end of the decade. The read/write heads themselves do not present a problem in increasing track density as they can be 'staggered'. But heat, and the fineness of mechanical resolution needed in positioning the heads, do present difficulties.

Access time

62 Improvements in access time will depend on an increase in rotational speed, a reduction in head positioning time, or a combination of both. Little if any change is envisaged in the former as it is considered that an optimum balance has been struck between size, driving power, wear, and the strains set up within the rotating surface. Research is currently being carried out into the possible use of air bearings but, whilst this may reduce the extent of wear, it is not anticipated that it will lead to significant improvements in rotational speed. Moreover, the use of an air bearing gives rise to the problem of the provision of a fail safe facility in case the air pressure drops.

63 Reductions in head positioning time will be modest. Average times are expected to reduce by about 25 per cent in the early 1970's, to 35–75 ms; and by 50 per cent to 25–50 ms by the later years in the decade. A reduction to

below 30 ms may be made possible by a different arrangement of the recording heads but any further reduction seems improbable because of the inertia of the head mechanisms, and the effort needed to overcome this in stopping and starting the heads, is a limiting factor. The most significant development in this area is, in fact, the elimination of head movement altogether by the use of one head per track. Although familiar in drum systems, this has only relatively recently been carried into the disc field. It looks like growing in popularity, because it provides greater reliability and reduces access time.

New disc file

64 One device currently under development deserves especial mention. It is a new type of disc file which consists of tensioned thin annular foil discs mounted in a hollow shaft. The discs are accessed by head mechanisms operating from within the central shaft. It is understood that it will have a capacity of 200 M bits, a data transfer rate of 327 K bytes and a head positioning time between 50 m sec (max) and 6 m sec (minimum). The read/write heads servo onto the data tracks and do not therefore depend on predetermined dimensional positioning. The device needs little power, it is small with a favourable power/weight ratio and is sealed in its environment. It is an attractive device which appears capable of further expansion. Where discs form a significant part of a computer system its adaption could lead to a reduction in accommodation requirements. Costs are not yet known.

Magnetic card devices

65 Little future is seen for magnetic card devices. The inherent weakness of the devices lies in the degree of mechanical handling involved. They will continue to have a place where a large file (in excess of 10^{10} bits) is to be held, and the activity rate is low.

Summary

66 To sum up. Modest improvements can be expected during the next decade in both the capacity and, to a lesser extent, access time of disc and drum devices. Cost reductions arising from the batch fabrication of electronics and, possibly, heads can be expected in the latter half of the decade. The trend towards the use of discs and drums will continue and they will gradually supplant magnetic tape in the main backing store area. It is anticipated that the small drum will gain ground in areas requiring less than a 20 m bit capacity, disc files will be used where higher capacity is required, and complexes of disc files where large files in the 10^{10} bit range are concerned. Cost reductions of the order of 2 to 3 have been predicted for these large files. Competition to small discs and drums (10 m bits) can be expected from batch fabricated memories in the mid-70's and, where speed is of particular importance, from mass core stores in the 5 m bit capacity range. The only possible contender to large disc files appears to be the magneto-optic memory, but this has yet to undergo considerable further development.

Memories*

Introduction

67 This paper summarises developments in immediate access stores of all types and capacities; and the research at present being carried out into a wide variety of high capacity backing stores. The use of magnetic disc, tape, drum and card for storage purposes has been covered elsewhere in this appendix.

Research

68 During the last decade the computer's requirement for immediate access storage capacity has doubled every two years, and it seems likely that this trend will continue. Research into the recording material of the store: the means whereby information can be recorded on, and retrieved from, it; and its manufacture; is leading to increases in speed and capacity, and decreases in cost and size.

Store organisation

69 There are also important developments in the organisation of storage within the computer system. The early concept of multi-level storage whereby a relatively small amount of immediate access storage was backed by a large amount of relatively slow backing storage (eg drum, disc magnetic card) is being extended to the organisation of the immediate access storage itself in the larger machines now being developed. A relatively large but very fast store is being introduced to serve as a buffer between the central processor the larger slower main store. This may, in turn, be served by a very large but relatively slow mass store. Storage at the main and buffer levels is often divided into a number of blocks so that the access of data (and instructions) from different blocks can be interleaved. In this way overall access time for a given volume of data can be reduced. Further reductions are being obtained in some cases by accessing several words of data at a time from each block. Together these developments in store organisation will enable an optimum balance to be struck between storage costs, and access time.

Store function

70 The prime function of a store is to hold data (and instructions) against the time when it is needed for computation or output. This is an essentially passive process. But the way in which the stored data is organised and accessed can lead to its use as an active element in the operational processes of the computer. Perhaps the best known example of a store organised for this purpose is the high speed associative store in which the store locations are addressed by their content, and not by their position in a matrix of storage elements. This has fundamental implications for the increased efficiency of the central processor: work involving access to several store locations can be carried out in one cycle which would otherwise take several cycles to execute. The concept of a virtual store becomes a practicable proposition; and the whole internal storage can

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* Memory, storage and store are, in general, synonomous. However, as certain devices have, in general usage, come to be described by one term in particular no attempt at standardisation has been made in the text.

be organised in such a way as to reflect the data structure of the problem to be processed (see paragraph 30 of this appendix dealing with the Basic Language Machine). Other applications of associative storage include its use for high speed look up tables (eg for tax purposes), and in pattern recognition devices (OCR).

71 Another interesting and potentially valuable development by the Royal Radar Establishment at Malvern is the 'Active Store'. This will enable lists to be processed by hardware at an average instruction time of 600ns, and lead to a significant gain in efficiency over existing software provision for list processing. This development has implications for improved efficiency in complex information retrieval systems.

72 The storage elements in both the active and, to a lesser extent, the associative store, are highly organised and interconnected. Their development has been and will continue to be bound-up with continued progress in the development of LSI.

73 Read only memories are another form of storage with a special function. To a limited extent they can replace the wired-in-logic of the processor. They enable some complex processes formerly carried out by software to be carried out more speedily by hardware. In some forms they may enable the instruction code of the computer to be more nearly matched to the particular problems it has to solve. These memories are examined in greater detail in paragraphs 78–83.

Ferrite core store

Immediate access stores

74 The ferrite core will in time probably cease to provide the main memory element. The continued development of thin film memories, especially plated wire, is expected to overtake it by offering greater speed at less cost where large or very large memories are required. It will probably be superseded by LSI memories in small but very high speed memories. Even so the ferrite core store is expected to continue in use until the latter part of the 1970's. The development of a machine for automatic core stringing, added to the existing facilities for automatic core moulding and testing, provide a high degree of automation in memory production with associated economic benefits. Smaller cores are being produced, and two are used per bit of information (at some penalty in cost) where very high speed is required. Cost reductions are expected to continue and store sizes ranging from 2 million words to 512 words and less, with cycle times from 3 microseconds to 300ns, will be available.

LSI

75 LSI is well suited to employment in memory devices because of the need for regular arrays of storage elements in the memory. It offers the advantage of very high speed and minimum external circuitry requirements. But, compared with the ferrite core, it is volatile (ie it will not store information when the current is switched off) and is, at present, much more expensive. However, in 'scratch pad' associative, and other small memories where high memory speed conditions the efficiency of the whole computer it undoubtedly has a leading role to play. Both Mullard and Ferranti are known to be working under

the Advanced Computor Technology Project (ACTP) on the development of LSI memories, the former on a 1024 bit store on a single chip of silicon. The uncertainties surrounding LSI costs have been dealt with elsewhere (see earlier paragraphs on LSI); but it is of some significance that the minimal need of LSI for associated external access circuitry leads to a near linear relationship between store size and cost, whereas the high cost of the circuitry to drive and access ferrite core stores becomes disproportionately heavy for the smaller store. In terms of speed and capacity it seems likely that LSI MOS memories of up to 1,000 words, and possibly more, with a cycle time of 50ns will be available by 1975, and it is possible that smaller LSI bipolar memories with cycle times in the region of 10ns will also be available by that date.

Thin film

76 The continued development of thin film memories, after the initial setbacks, is leading to their use both in very high speed small memories and in much larger main memories. While slower (100ns cycle time in their fastest form) than LSI memories they are expected to be significantly cheaper, and, by 1975, to find a place in small fast memories (eg 1K–2K words) where the cost of LSI cannot be justified. The long-term future for thin film in the larger memories is problematical and will depend largely on the progress made in the development of plated wire. Although a little slower than planar thin film, plated wire memories offer other attractions. Amongst these are the possibility of non-destructive read out (NDRO), the need for less complex supporting electronics, and the consumption of less power. It is understood that the feasibility of constructing a 16 million bit plated wire memory has already been established. If the present difficulties associated with the production of plated wire with satisfactory yield can be overcome, it is anticipated that memories with capacities ranging up to 4 million words, and with cycle times rising from 1 microsecond (for the largest store) to 400ns (for the medium size store), will be available by 1975 at a cost which may be half that of planer thin film memories. The commercial production of a cheap 'rod memory' computer by NCR for use in their century range of computers, shows promise. Rods, 110 inches long and ·006 inches in diameter are used – memories with capacities up to 524,000 characters and with a cycle time of 800ns are to be produced. The economic feasibility of this particular memory is attributed to fully automatic fabrication including magnetic positioning of the rods in the memory plane. Unlike other plated wire memories it is not thought to be capable of non-destructive read out. This is a disadvantage where the very highest speeds are required.

Batch fabricated memories

77 Development work is at present being carried out into the mass fabrication of memories by etching toroids on thin permalloy sheet of 10 micron thickness. Memories of a 10 million bit capacity are considered feasible. It is estimated that such a memory, with its associated electronics would occupy a total volume not exceeding six litres. Power requirements would be low; access time (non-destructive read out) is estimated at about 10ns and cost may be as low as 1/10d a bit. If successful this memory has obvious attractions as a mass immediate access store; and would present a serious challenge to the

small magnetic drum. Its commercial availability by 1975 or a little later is thought to be possible.

Read only memories

78 Read only memories (ROM) are already used in a number of computers (eg IBM 360 series) to implement the micro-programs which combine to make up the instructions order code of the computer. In so doing they replace some of the wired-in logic by a relatively flexible form of logic. They are cheaper to produce but, only, in some forms, at a price in terms of reduced operating speeds. ROM can also be used for code conversion, including the emulation of the instruction code of one computer on a totally different one, and the execution of some relatively complex functions which were formerly carried out by software.

79 Current research and development in this field is, in the main, concerned with achieving higher operating speeds, increasing the storage capacity, decreasing cost and improving flexibility. It is not possible to provide comprehensively for these advantages, and ROMs of different constructions are being developed, each aimed at maximizing at least one of the desired qualities.

80 Flexibility is provided by the ease with which the information stored by the ROM can be changed. In some machines the ROM can be changed relatively quickly on site by a computer engineer. In others now under development the information stored in the ROM can be changed electrically without need physically to remove the ROM storage material (known as 'fast read, slow write'). An interesting development by Univac is the production of a ROM based on a set of magnetic plates on which 'magnetic bits' are created by recording heads. When a plate is placed at the side of a set of wires it creates a flux in the wires wherever a bit has been recorded on them. The information thus recorded can then be read from the wires to play its role in the function of the computer. The magnetic plates can easily be interchanged. This gives a high degree of flexibility. A high read out rate is also claimed.

81 The fastest ROMs will undoubtedly be based on LSI, cost and capacity will depend on developments in this technology. Olivetti are also understood to be developing a very high speed ROM based on the transmission of light pulses through optic fibres. Where binary 'I' bits are to be recorded the fibre is either scored or painted. When light is later pulsed down the fibre it is scattered where the scratch or marks has been made and detected by a photodetector at each marked position which converts the scattered light into a binary pulse. Nano-second read out times are claimed.

82 The braided transformer memory designed at the Massachusetts Institute of Technology has the advantages of cheapness and large capacity. It is now being marketed in America. A loom driven by input to a paper tape reader is used to braid information at high speed into the weave of a wire harness which is later encapsulated and assembled into electronic boards. A storage capacity of up to one million bits and more is claimed.

83 It is clear that if successful, the further developments of ROMs will bring even greater flexibility to the computers which will be developed over the next decade. They will also play a part in cost reduction and in the implementation of some software functions at present carried out by hardware.

High capacity backing stores

84 Extensive research is currently being carried out into a wide range of physical phenomena and associated systems which appear to offer potential for the development of backing stores of immense capacity. The use of the laser beam, a source of coherent light capable of being focused with a very high degree of resolution, figures prominently in many of the developments; drawbacks are that it requires optical and mechanical systems of a very high order of precision, special environmental conditions and, in most instances, a separate development process.

Unicon store

85 This store is based on the use of an argon laser to burn minute holes in the coating of a helically transported 16 mm tape. The holes represent binary '1's. They are read by directing a lower power laser beam onto them; the light emerging is then converted by photomultiplier units into electrical impulses. A capacity of 645 million bits per square inch is claimed; on this basis one 2,400 foot reel of tape would hold enough binary information to fill many thousands of reels of magnetic tape. The read out process is apparently the greatest difficulty in the development of this store.

Magneto-optic store

86 This store utilizes the laser beam to change the direction of magnetism in very small areas of a ferromagnetic film of manganese bismuth. Each area stores a binary bit. Read out is achieved by use of the magneto-optic Faraday effect whereby polarized light passed through glass parallel to a magnetic field is rotated in proportion to the degree of magnetization. Clockwise or anti-clockwise rotation will occur depending on the polarity of the magnetization, and thus enable '0' or '1' bits to be identified. A packing density of between 6 and 24 million bits per square inch with a read out rate of 100 million bits per second are considered feasible. Honeywell have an interest in the development work. A body of opinion considers that the prospects for the success of this technique are greater than for others using the laser beam.

Laser-hologram

87 Development work is apparently being undertaken on this technique, and reports in the technical press suggest that some form of viable holographic store is likely to result. Briefly, the technique uses an helium/neon laser to store binary bits on a plate, usually photographic, in the form of a large array of mini-holograms. The information is read out by the use of another laser beam which reconstitutes the original image of discrete information bits at a read out plane comprised of sensitive photo-transistors. This store has the great advantage that dust settling on the hologram storage plate has little effect on the retrieval of the stored binary information. A store comprising 1 million bits with a read out time of 20 microseconds has already been produced. All the disadvantages recorded in paragraph 84 apply to this store. But several developments are at present in hand to overcome them. RCA are working on the production of holograms on a manganese bismuth coated mica film, using the physical effects described in the preceding paragraph on the

magneto-optic store. If successful this approach will overcome the limitation of the photographic storage plate which, up to now, has virtually confined the Laser-Hologram store to the read-only category. A storage capacity of 100 million bits per square inch is considered feasible, with a writing time of 10 microseconds and an erasure time of 20 microseconds. IBM Ltd is known to be developing a new cheap light deflector switch believed capable of the precision needed in this application but it is a relatively slow device. Bell Laboratories in America are developing a deep, or volume, holographic store and claim that 1 million bits may be stored in a one centimetre cube of lithium niobate. In the UK Plesseys are also known to be interested in the development of this type of store. Although the outcome of this intensive research cannot be predicted there can be no doubt of the significance of its success for the establishment of large data banks.

Sonic memory

88 This store is in the very early stages of development by RCA. One of the main advantages claimed for it is a read out time of less than one microsecond. The store comprises magnetic film strips deposited on glass substrate such as fused silica. Sets of conductors, wired to amplifiers, are suspended above the film. The writing and reading digital information to and from the store is achieved by the 'piezo-magnetic' effect. Advantage is taken of the fact that a state of magnetization can be more easily changed if the material magnetized is subject to strain. Strain in this store is produced by the passage of some pulses through the substrate.

Other backing store research

89 For some years research has been carried out to determine whether a high capacity store can be based on the phenomena of superconductivity at very low temperatures. There has been little success with the development of the cryogenie store based on this phenomena. The cryoelectric store, which also requires temperatures approaching to absolute zero, may possibly be more successful. Research continues. One of the major drawbacks with these stores is the use of expensive liquid helium to maintain the very low temperatures required. Other research is being carried out into the use of minute magnetic bubbles for storage purposes; into the possible use of optical delay lines using light as the storage medium; and into the possibility of establishing biological stores.

Summary

90 The increasing demands for immediate access storage over the next decade will be met by a range of storage devices each offering, at reducing cost, increases in speed and storage capacity. As these three factors are not compatible an optimum balance will be struck by the continual use and development of highly developed store hierarchies each related to the speed at total immediate access storage requirements of particular computers. Thus, at the highest level, we may expect to see LSI memories of up to 1,000 words capacity with cycle times between 10 and 5 ns. Between capacity requirements of 1,000 and 2,000 words planar thin film may be the popular choice with a

cycle time in the region of 100 nanoseconds. Storage requirements of between 2,000 and several million words (400ns–1 microsecond access time) will probably be provided by plated wire, and possibly, by rod memories where some speed can be sacrificed to save cost. Mass immediate access memories of greater capacity, may, in the early years of the next decade, be based on the ferrite core, but will probably give way to cheap batch fabricated memories of thin permalloy sheet (10 microseconds access time).

91 Developments in LSI are expected to lead to the increased use of associative and other highly developed stores. These will have a significant effect on machine system designs and efficiency.

92 The use of read only memories is expected to continue and to be developed to provide increased speed, greater capacity, or greater flexibility as may be required by particular machine system design requirements. Overall cost is expected to come down.

93 Beyond 1975 current research into high capacity backing stores may begin to result in store of high capacity becoming available. The use of laser beams is the subject of intensive research. Although no prediction can be made a body of opinion believes that the magneto-optic store offering storage capacities up to 24 million bits per square inch offers the best likelihood of success. If the research effort being expended on the Laser-Hologram store bears fruit capacities up to 100 million bits per square inch are considered possible.

Peripherals – Printers

Line printers

94 Line printers fall into two main categories, the impact type, and the non-impact type. The former type at present predominates and prints by the impact of a print hammer against a character font embedded in a rotating drum, or in a slug fitting into a chain loop or oscillating bar. The latter, exemplified by the Xeronic printer in the early 1960s, prints by chemical, electrostatic or similar means.

95 Currently, maximum speeds of up to 1,400 lines per minute are being obtained from line printers with a reduced, 48 character, print sets. If the set is reduced to numeric characters only, a speed of 2,700 lines per minute can be achieved without difficulty. Improvements in speed are expected to follow from improvements in print hammer design, in the method of inking the hammers, in printer paper, and in the manner in which the paper is fed to the printer. If the improvements are reasonably successful a maximum speed of 3,000 lines per minute, with a 48 character sets, might be achieved. Higher speeds are considered to be beyond the capability of devices working on the basis of electro-mechanical systems.

96 So far as inking of the print hammers is concerned it is understood that research is also well advanced into the use of inking rollers, as used in printing machines, in place of print ribbons; and the possibility of presenting paper to the printer in roll form is being considered. Much will depend upon the demand for printers with higher speeds, and the price the user is prepared to pay. The emphasis is, increasingly, on the production of consistently good print quality, an emphasis owing much to the increasing importance of OCR techniques in the data processing field.

Cheaper printers

97 While high speed may be desired in high throughput applications the need for a slower but very much cheaper machine for use as a terminal device in data networks is envisaged. To meet this anticipated demand one manufacturer is devoting efforts to the production of printers by fully automated processes. Printers with speeds up to 1,000 lines per minute are being considered.

Non-impact printers

98 Non-impact printers have a number of advantages. The advantages include large character repertoires, high speeds, and significant noise reduction. The size and shape of font can be changed to create drawings and graphs etc as well as to reproduce various print styles. The non-impact printer will also produce constant format lines and thus print form outlines. The main disadvantage lies in the very high cost of the equipment and, in some cases, the cost of special printing paper.

99 Although much development is clearly being carried out in this field it is difficult to establish progress. The Japanese are reported to have a non-impact printer operating at 9,000 lines per minute and have, experimentally, achieved speeds of 18,000 lines per minute. Special paper which changes in colour under the influence of electro-static charge is understood to form the basis of this machine. Little is known of US efforts in this area but significant progress is believed to have been made. Eighteen months ago a British manufacturer produced a full-size experimental machine capable of producing OCR quality print at 12,000 lines per minute. A maximum speed of 26,000 lines per minute is claimed to have been achieved with a reduced line width. This printer makes use of magnetic ink powder. 3,000 magnetic heads are located across the length of a revolving drum and characters are recorded, on a matrix basis, by attracting the ink to magnetized dot areas on the drum. This is subsequently transferred to the printing paper and fused on to it (any paper can be used). This printer has its own storage and is able to produce fonts of different styles and sizes. It is estimated to cost about £35,000. Work is still progressing on this machine but it appears to have relatively low priority compared with other developments. One of the main problems lies in fusing the magnetic ink to the paper.

Operator aids

100 Higher printing speeds underline the need for more effective operator aids. This is especially so in relation to the stacking of the paper once it has been printed. Dynamic stackers are now available with some machines and improved versions are expected for use with the new printers. A few machines already provide for automatic tensioning in setting up paper on the printer. This trend is expected to spread as time lost on setting up peripheral equipment becomes more expensive as the peripheral get faster and the computer more powerful.

Character printers

101 Character printers fall into main categories; those associated with keyboards which, at present, tend to an average speed of 10 characters a second,

and those not so associated which are driven either directly by the computer or by paper tape. Speed range of these machines lies between 40 and 60 characters per second. Unlike line printers which normally have buffer stores, character printers are unbuffered. They are considerably cheaper and the printed information can be read as it is produced.

102 Development is well under way to produce keyboard character printers working at 20 characters per second. A machine was put on market in France earlier this year capable of this speed, and it is understood that Britain may soon be marketing a machine of similar performance. This apparently small increase in speed is linked with the anticipated use of a 200 bit per second (Datel 200) transmission line. This service will enable a 7 bit character code to be used. This will increase the available character repertoire, and allow for peak performance by an operator at the full 20 character per second speed. Paper tape input could also be used to drive these machines.

103 As with line printers, the character printer without associated keyboard can be placed in one of two classes; the conventional impact type of machine, and the non-impact chemical, electro-static etc type of machine. The former costs in the region of £3,000 for a speed of 60 characters per second and produces good quality print. Machines working at 20 characters per second are available and substantially cheaper. The non-conventional machines offer a wide variety of choice. One machine makes use of chemically treated paper, is silent, and works at a speed of 60 characters per second, but the print quality is not considered good enough for OCR reading. Another machine, known as the inktronic printer, forms its characters from a matrix of ink dots. It works at 60 characters per second, is very quiet, and has a high MTBF. It works on the electro-static principle but produces print of relatively poor quality. Where permanent hard copy is not required a machine is available working at 60 characters per second which forms characters out of magnetic particles on a band film. It produces a good quality print and character sets (including symbols), can be easily changed. Although not permanent the character remains visible on the machine for as long as is required. It can then be wiped off. Developments with the non-conventional type of character printer are expected to concentrate on improvements in convenience and in print quality.

Summary

104 Development in line printers is directed as much to print quality as to speed. Improvements in quality will continue so that the printed output can be read by OCR means. Printer speeds will also increase but the electro-mechanical considerations are regarded as placing an upper limit of 3,000 lines per minute on the impact type of printer. If demand is sufficient, it is anticipated that printers with this performance will be commercially available by the mid-70s. The development of non-impact printers will provide flexibility in the form of a large character repertoire (useful where information retrieval requires upper and lower case characters, as well as in scientific applications), and a facility for format printing including the production of line drawings for graphs, maps, etc. Very high printing speeds will be possible but it may be some years before cost reductions makes this type of printer viable on speed grounds alone. Developments in the automated production of slow speed impact type line printers are expected to lead to a significant reduction in their

price. This is a promising move so far as future data network developments are concerned. Improvements are also anticipated in operators' controls and in the facility with which printed paper can be stacked. Character printers with keyboards operating at 20 characters per second are shortly expected on the market. They will enable full advantage to be taken of the Datel 200 service by offering a fuller character repertoire and a modest speed increase. Little significant development is foreseen in conventional character printers without keyboards but the non-conventional, non-impact type will develop further and will be quiet and reliable.

Data collection

Introductory

105 The collection of data and its conversion to machine readable form for processing by the computer have for many years been the weakest links in the computer process. Especially in the ADP area it has accounted for the greater part of the staff employed in the process.

106 A need exists in the scientific and process control fields for the collection and conversion of data at source as it is generated. This need has been met by interfacing the recording instrumentation (via analogue to digital converters as appropriate) either on-line direct to the computer, or off-line to paper or magnetic tape equipment for logging and subsequent entry to the computer. The refinement of recording devices and the advent of solid state electronics have led to improvements in this area both in terms of accuracy and convenience. The development of LS1 is expected to lead to further steady improvement but no revolutionary changes are foreseen.

107 The traditional method of collecting data by transcription from the source document (often via a specially prepared punching document) by manual keyboard entry machines onto paper tape, punched card or magnetic tape for subsequent entry to the computer carries a very heavy staff overhead. This method is expected to continue, and developments in this are being directed to achieving economies. Significant development is also taking place of equipment for converting data at source either by the direct reading of source documents employing character recognition techniques; or by the direct entry of data via keyboard terminal, visual display unit screen, spoken word or tone input.

108 The use of paper and magnetic tape produced as a by-product of an accounting or other machine process is also developing. So is the use of devices capable of reading fixed information in coded or plain form on plastic 'credit type' cards to which may be added variable information entered directly into the device by keying or some other method.

Traditional method-data preparation

109 Little significant development is envisaged in conventional punched card and paper tape preparation equipment. Worthwhile improvements have already been made in the ease with which the equipment can be operated, and in the flexibility to cope with a wide variety of work with the minimum of disruption. This appears to be the limit of development. The use in commerce

of equipment for the direct encoding of data onto magnetic tape has increased during the last 2/3 years and manufacturers of the equipment predict a rising demand. Controlled tests so far carried out in Central Government do not support the claims made for this equipment. Unless other factors (eg lack of storage space for cards; staff appeal of magnetic tape machines etc) assume greater importance than at present seems likely little future is seen for this equipment in Government.

Input to mass store

110 A more promising development lies in the use of a small computer to control input from a number of keyboards and place it on magnetic disc, or in mass storage, for subsequent transfer to the computer. Systems using a disc already exist and further refinements are envisaged. They are considered viable for relatively small numbers of operators (12 to 30). Their main advantage lies in significant hardware cost savings; they also improve working conditions (reduction in noise, absence of bulky recording material to handle). The use of a mass store in place of a disc as the intermediate storage medium may make possible greater savings and a much greater sophistication of application. This system is thought to be viable for operator groups of between 30 to 60 or more. Complemented by efficient software (which is a problem area) and a more powerful computer than can be associated with the disc, mass storage should enable validation of data to be carried out at the time of data preparation. This would save the time at present spent verifying correctly recorded invalid data and the computer time involved in rejecting such data. Paper flow through the system would also be simplified, as would the collection of management control statistics. Some staff savings (not exceeding 10%) may be achieved. This system is being actively considered by TSU in association with CSD, and it is hoped to initiate a pilot scheme within the next year.

Capture of data from source documents

111 Magnetic ink character recognition (MICR) has been invaluable to the Banks in their work of processing cheques. The high protection it offers against fraud and the freedom of the characters from corruption by overstamping is considered to outweigh, in the banking application, its several disadvantages. It is a costly system in that it demands high precision in printing and good quality paper. The normal line printer cannot be used for printing it; and the characters used, particularly the E13B font, are highly stylized and difficult to read. No new application for MICR can be foreseen. As Optical Character Recognition (OCR), develops it is possible that the use of MICR in banking will decline.

112 The growing demand for the reading of source documents has led to advances in OCR and the promise of fundamental developments to come. Effort has been concentrated on reading methods, two of which offer particular advantage with defective print and characters with variable pitch and limb width (such as hand print). Up to the present OCR has been carried out, off-line, and mainly by hardware. Anticipated developments include the linkage of the OCR equipment on-line to the computer; and the use of software both to improve reading efficiency (scope and quality) and to enable editing and

other processing work to be carried out during the reading pass. It should then be possible to read unformatted documents bearing typewritten, lineprinted, letterpress and hand printed numerals (with some additional characters) in a mixture of different fonts. Credibility checking, including reference to computer stored information about earlier transactions, should also be possible. Diagnostics should be improved: this would reduce down time and secure fuller utilization of the equipment.

113 Much effort has gone into attempts to read handwriting. This research falls within the field of pattern recognition and has been approached from several different directions. As yet, no acceptable system has been produced. Progress will depend on the amount of support this research receives, but it is highly unlikely that other than a constrained form of handwriting will be readable.

114 The use of OCR even when fully developed is not expected to replace entirely the traditional method of data preparation. Much will depend on the design of suitable systems, on the amount of data to be read, and the extent to which the documents to be read can be secured for processing in an acceptable condition. The difficulty of achieving a standard font, allied with cost and technical problems, has so far delayed the widespread use of the technique. With the gradual resolution of the latter increasing pressure will be brought to bear on standards.

115 In addition to reading from source documents, OCR can be used in conjunction with typewriters in place of conventional data preparation machines. This approach poses verification problems but it offers considerable economies in equipment capital costs, and facilitates data preparation at dispersed locations.

Voice input

116 After many years of research, progress in this field has so far been limited to the recognition of clearly enunciated numerals. Further progress is difficult to predict and the place of this method in Government ADP is problematical. It is certainly difficult to envisage a major place for this method within the next 10 years or so.

Tone input

117 The development of the key or touch-tone telephone and its anticipated introduction by the GPO within the next 2/3 years offers the facility of an elementary data input device (numerals plus a small number of control characters) wherever a telephone is available. The implications of this development both for Government and the private sector are profound.

118 The present ability of ADP equipment to store words on a drum and, in reply to an input query or problem, to link them together and transmit them as an audio response offers the practical possibility in conjunction with the Keytone telephone of a two way terminal.

119 Development on the lines above mentioned is already well under way and can be expected to grow in pace. Portable devices are now available which, when linked to the telephone handset by acoustic coupler or a magnetic device, provide the two way service. They also enable the limited amount of

data (up to 50/60 characters) to be verified before transmission and then transmitted at a fast rate – thus increasing accuracy and divorcing the computer input operation from the speed of human key pushing.

120 It is understood that the GPO are shortly to approve the design of an acoustic coupling device in this country. This would open the way to the use of portable devices by travellers (salesmen, visiting civil servants etc) through the local telephone box, and by local offices, at little cost.

Video and keyboard terminal input

121 These devices are already well known and are coming into increasing use, mainly for interactive computing developments in computer graphics, including the ability to provide and receive information in graphic form. Much remains to be done in relating the facilities offered to the precise needs of the user. This is a matter mainly of software design and user education. The development of a cheaper video terminal is now overdue and would add significant impetus to the use of this device. Advances in both facility and cost reduction can be expected within the next few years.

122 Potential also exists for the replacement of the electro-mechanical teletype terminal by the faster, quieter and more reliable digital visual display unit. This course is already being followed in a small number of applications. Anticipated cost reductions are beginning to appear and will provide an impetus to change.

Pencil follower devices

123 The use of pencil follower devices for digitizing special information eg map locations, engineering component designs etc is already well developed and will continue to be used in surveying, establishment of coordinates for reference purposes, industrial component production etc etc. No significant developments are expected in this area.

Summary

124 Discernible trends in the development of data capture during the next decade are:

(a) the integration of data capture devices with the computer to improve the efficiency of the capture process, and to enable validation and other processing work to be carried out during the capture process;

(b) a move towards the capture of data from source documents as OCR techniques develop, complemented by a corresponding decline in conventional data preparation methods;

(c) the widespread availability of simple data capture devices such as the keyphone;

(d) the replacement of electro-mechanical keyboard terminal devices by digital visual display units in many applications as cost reductions become effective.

125 Trend (a) should produce small savings in data preparation staff, and lead to the design of more effective processing systems. Trend (b) will produce substantial savings in data preparation staff. Although no figure can yet be given for this saving it is clear that not all applications will be able to

make use of the technique, and that where it can be used it must be regarded as a fundamental factor governing systems design. The widespread use of the keyphone as an elementary data input terminal (item c) must depend on the speed with which the GPO can provide the service on some scale and on the design of systems to make effective use of it.

Multi-access systems including data transmission

Introduction

126 The pattern of a number of users in different locations sharing a computer through data transmission links has developed in the past two or three years. It has been forecast as the way in which powerful computers will be most frequently used, and be made available for an ever widening range of tasks. Extravagant predictions have been made for an explosive growth in multi-access systems in the UK. The systems currently under development vary in a number of ways, and as yet there is no standard terminology. To avoid confusion the term 'multi-access' in this paper has been used as a generic term intended to cover (a) real time systems, ie systems mainly dedicated to a particular task and requiring a machine response within the time needed to control external events; (b) time-sharing systems used for interactive program development, information retrieval etc; and (c) remote batch processing whereby data is input remotely for subsequent batch processing at the centre. Each of these systems may, in turn, share the computer with batch processing work carried out on site as a background task.

127 The future development of multi-access facilities depends heavily on the availability of adequate data transmission facilities at an acceptable cost. These in turn are directly related to demand. Four firms have entered into contracts with the GPO to determine the demand and the way in which it can best be met. Until they all report the nature and cost of future data transmission facilities will be uncertain. While the provision of data transmission facilities will play an important part in the development of multi-access systems, the availability of efficient software and hardware is of prime significance. There have been many difficulties in the provision of these items, especially efficient operating software.

Hardware and software considerations

128 The hardware and operating software requirements of multi-access systems range widely. Maximum response times, incidence of peak loads, tolerance of down time, accuracy requirements, ratio of active to passive terminals, volumes of data to be transmitted and nature of processing vary, and result in system requirements which are often unique. Progress in the development of large multi-access systems has been slow and there have been many set-backs. Development in hardware, including large powerful computers, and a more realistic appraisal of requirements has led, in the last two to three years to some modest successes. Software development continues to dominate the situation (some dedicated systems have been stated to require between a half, and one million instructions), and it is significant that most

users have found the software provided by the computer manufacturer to be inadequate for their needs. More than one eminent authority has expressed the view that the software requirements of complex multi-access systems are beyond the ability of the most expert programmer to satisfy. The development of data concentrators, or front end processors, to relieve the central computer of much of the housekeeping work involved in multi-access lends support to this view. This type of development will undoubtedly continue. A parallel trend, found in dedicated systems such as those being developed for the banks, makes greater use of terminal equipment to carry out data validation and certain housekeeping functions, as well as providing in some instances a 'fail soft' facility should the central computer fail.

High capacity terminals

129 High capacity remote terminals have for some years been used for the input of data for subsequent remote batch processing. Recent developments include the use of more powerful terminals, with full housekeeping facilities and capable of message packing (eg elimination of redundant characters) working at a transmission rate of 4.8 K bits per second. These terminals include line printer output facilities and card input facilities. The University Computing Company's system which is built round this type of terminal makes no use of the powerful multi-programming facility of the large central computer as the designers of the system believe that the reduction in calls on the computer for housekeeping leads to a greater throughput than would be obtained in the multi-programming mode. A current attempt to offer interactive programming in association with remote batch processing using the same large computer makes use of a small computer to handle the terminals and simple computing tasks. The small computer has access to the larger computer for complex calculations, and to that computer's high capacity backing store for files.

Commercial systems

130 The growth of commercial systems offering a limited facility for program development and computation has satisfied a need for this service. In part successful development of these systems is attributable to their limited objectives and staged evolution. The recent announcement of cheap time sharing systems based on small but powerful computers (eg a system capable of serving 32 terminals is estimated to cost £45,000) may make possible an in-house facility in establishments where the provision of such a facility based on a distant large computer would be uneconomic. The growth of commercial systems for accessing data from a common bank (eg stock exchange information on share prices) has been less rapid but no less significant. It seems probably that the development of multi-access facilities for this purpose will gain in relative importance over interactive program development, and computation, as data banks are established. The number and geographic location of the linked terminals in such a system must clearly be related to the nature of the information held in the bank. These systems may well be developed gradually from small beginnings.

Interactive programming languages

131 The development of languages for use in interactive programming has led to a number of special purpose languages such as JOSS, BASIC, and, more recently, POP-2; and to the provision in some existing languages, especially FORTRAN, of the facilities needed for this mode of operation. Development is anticipated in the provision of more powerful facilities including easier data manipulation. This has been a somewhat neglected area due to the earlier preoccupation with computation.

Developments in terminal equipment

132 Two forms of terminal development deserve particular mention. The first is the introduction of the touch tone telephone, and the second the development of visual display units. The former will provide a cheap and readily available means of direct data input to the computer. It may be supplemented by the attachment of accoustic coupling devices to existing telephones (the GPO have recently published a Code of Practice for the manufacture and use of these devices). They could give rise to a substantial increase in demand for multi-access facilities. The latter offers superior facilities to the keyboard terminal both in speed and quietness of operation. Cost has so far limited its widespread adoption. But the development of the storage display tube, with a slower yet adequate response time, and an anticipated all-in terminal cost of £1,000 or less, will open up a much wider field of application. The further development of VDUs lies in the provision of a simple vector capability for management use (graphs etc); and in the development of software to enable it to be employed on problems with a hierarchical decision structure.

Computer to computer communication

133 The facility for core to core transfers at speeds approaching the internal speed of the computer is, at the present time, limited by economic considerations to distances of the order of hundreds of yards. While this is sufficient for multi-processer operation within an installation, and provides a fail safe facility in critical real time applications, it does not permit rapid load shedding and sharing over a network of inter-linked computers. The development of an economic wideband transmission system to serve a network of view-phones could, in time, be an answer. In the meantime the anticipated provision of a 48 K b.p.s. switched network offers the possibility of transferring large volumes of data between computers at a reasonably fast rate.

Standards

134 The proliferation of dedicated private multi-access networks, and the possible evolution of larger public and private ones from small systems, raises the important question of agreed standards for message formatting and transmission. Linkage of systems and access to information of common interest to several users could well be impeded if a variety of different standards are adopted. The importance of this has already been recognised and a B.S. Institute standard for half duplex operation using a 7 bit code is about to be issued.

File security

135 The need to prevent unauthorised users getting access to confidential data has already been the subject of public concern. Means exist, both in hardware and software, for restricting access to data, and have already been implemented in some systems. Absolute protection is not considered feasible although protection to a high degree is attainable.

Data transmission facilities

136 At the present time a total of only 3,000 data terminals is believed to exist in the UK, and, until the results of the market survey studies referred to in paragraphs 2 have been considered, the GPO is believed to be planning on some 50,000 terminals in 1975, a growth rate of approximately 100 per cent. Telephone installations on the other hand are growing at the rate of only 6–7 per cent, but there are already 12 million of them.

Current GPO facilities for data transmission

137 The GPO Datel services currently cover a range of transmission rates, and offer a variety of facilities. The telex service, Datel 100, operates on both private lines and public switched network lines, and offers a service to users able to transmit data in five bit Murray Code from paper tape input. Datel 200, which is used by concerns offering a time-sharing facility, enables remote terminals to be operated at full manual input speed using a full set of characters and selected symbols. This service will soon be available internationally. Datel 300, a recently introduced service, offers a cheap means for collecting small quantities of data from remote locations using card, paper tape or keyboard input. As a medium speed service, Datel 600 is capable of offering a transmission rate of 1,200 bits per second, especially over a private line, with a guaranteed speed of 600 b.p.s. Datel 2,400, which uses private lines and offers a duplex capability, has also been introduced recently. It will link high capacity terminals to a central computer. A transmission rate of 4.8K b.p.s. is being achieved consistently by one commercial firm with suitably designed modems and private lines. Limited facilities exist for offering a 40.8K b.p.s. private line service but high cost appears to have discouraged its use.

Future developments

138 Development of the facilities offered by the existing Datel services is expected to continue and will secure the fastest transmission rates possible within technological and economic constraints. It seems possible that a further increase to 7,200 b.p.s. may eventually be achieved. Datel 400 will be of particular interest in scientific and engineering applications as it will enable both analogue and digital data to be collected from remote measuring instruments. It is expected to be available in 1970/71.

139 The GPO are also developing a 'Dataplex' service which will offer customers of remotely located time-sharing bureaux long distance calls at local rates. It is understood that this will be effected by routing the calls originated over the local switched network via a leased private line to the bureau computer; this line will be used in a multiplexed mode and enable

several customers to use it concurrently. Although the private line and multiplex equipment will have to be paid for, presumably by the bureau, it is anticipated that this arrangement will be more economic than the present one, as well as offering a particularly attractive rate to the customer. This development could have significance for slow speed Government networks but, as yet, no cost details have been made known.

140 The introduction of an experimental, manually switched, 48K b.p.s. wideband service between London, Manchester and Birmingham next year will, if successful, provide an economic high speed service to those capable of taking advantage of such a wide bandwidth. If there is sufficient demand for the service it could become a permanent feature available, with automatic switching, over an ever widening area over a period of years.

141 The conversion of a growing number of GPO junction networks to the transmission of speech using the pulse code modulation (PCM) system; and the known ability of this system to convey digital data over a twisted pair of wires at a rate of 1.5 M bits per second, has been claimed as an answer to data transmission problems. This is not likely, at least within the forseeable future. Full advantage of PCM can only be secured if the total GPO system – ie the local, junction and trunk networks – are all converted to this transmission system. This is an enormous task requiring heavy capital investment, and extensive technical resources. This may well be the ultimate system, but its development is considered to be more than a decade away.

142 The development of the viewphone and the demand which may be generated for it (Japan and the USA expect to have an expanding system by 1975) could well have a dramatic influence on the cost and availability of facilities suitable for data transmission. With a bandwidth requirement of 1 MHz (or 6 M b.p.s. if implemented by digital techniques) its provision on a wide scale has obvious implications for the speed with which data can be transmitted. It seems highly unlikely that significant provision for this service will be available in the UK within the next decade. The following decade could see its widespread introduction, and the consequent provision of high speed data transmission at greatly reduced cost.

143 Up to the present facsimile transmission has not been favoured, partly because of its slow rate, for conveying information from remote locations to a central computer. Renewed interest is now being shown in the technique, and Recognition Equipment (an American company) claim to have linked the technique with the facilities offered by OCR to provide an economic means of data collection.

144 The use of satellites for data transmission over long distances has already been developed for some applications (eg world-wide airline seat reserving schemes). Its use over short distances is not thought to be a viable proposition.

Digital data networks

145 The technical requirements of telephony, for which the present GPO system was largely developed, and those of data transmission, exhibit wide differences. Communication by speech falls into a limited range of easily definable time periods and requires a bandwidth not exceeding 4KHz to

convey full intelligence. Data, on the other hand, can be transmitted for periods ranging from milli-seconds to hours, and at bit rates ranging from bits to megabits per second.

Store and forward network

146 This situation underlies the development of a message switching digital data network for data transmission purposes pioneered at NPL and now being studied in parallel with proposals for a circuit switched digital network, by the GPO. The message switching network would operate on the store and forward principle. It is seen as a possible nation-wide network of high speed digital lines (using GPO facilities wherever possible) linking together a number of 'nodal computers' which control the transmission and routing of standard data packages (128 characters or less) at very high speed within the network. The packages are assembled by interface computers linked on one side to the nodal computer, and on the other to individual terminals or systems of terminals. Advantages claimed for the network include:

(a) effective provision for all data transmission requirements (man to computer eg data input, inter-active programming; computer to computer eg transfer of information from core to core; and machine to computer eg telemetry, process control);

(b) control of transmission, including accommodation of a wide variety of transmission rates, is taken away from the local terminal and carried out by the inter-face computer;

(c) provision of the equivalent of a private line without tying up equipment;

(d) greater flexibility in that advantage can be taken of technological developments without having to replace older equipment.

147 Significant overall cost savings are anticipated from the use of such a network, although it is admitted that the cost of linking individual terminals to the interface computer (currently estimated at £1,200 including a share of the interface computer costs) would be disturbingly high. The introduction of cheap LSI could improve the position. The outcome of the study now being carried out by the GPO must be awaited before the place of this fundamental development in data transmission systems can be assessed. If a decision is made in favour of either a store and forward message switching network, or a circuit switching network, implementation on any scale is expected to take at least five years from the date of decision. It is understood that the GPO intend to make a decision on the implementation of a digital data network, in one form or another, in 1970.

Costs

148 Costs depend in part on demand. As the cost of low and medium speed switched network facilities, apart from the Telex service, is the same as for the telephone service (plus modem rental) it is significant that, in constant money terms, the cost of long distance calls was reduced by approximately 50 per cent in the period 1945/65. A midnight line service permitting unlimited use between midnight and 6 am for a modest fixed rental has now been introduced. A continued reduction in rate is anticipated by the GPO as investment

in telecommunication facilities grows. What is not known is the rate at which costs will come down and the limits on the reduction.

149 Where private lines are used cost is related to distance and transmission rate. Although costs for a switched 48K b.p.s. service are not yet known, it is reasonable to expect that the reduction in costs associated with increases in transmission speed will result in increased economies. With relatively slow terminal devices economic considerations point to local networks of terminals linked to communication computers which would, in turn, be linked by high speed lines to the central computer.

Conclusion

150 The extensive use of multi-access systems, and the pace at which their introduction will take place depends on the progress made in developing appropriate hardware and efficient operating software, and the design of efficient systems to exploit these facilities. It depends also on the availability of a range of suitable data transmission facilities at acceptable cost.

151 Cost is, to a large extent, dependent on total demand. Despite the many predictions made for the rapid growth of demand in the UK market, little reliable information has been available. The GPO are now considering the results of the survey carried out by SCICON on their behalf. Future provision must depend on the outcome of this consideration including the findings of the three firms commissioned to report on the way in which the demand can best be met. It is encouraging, however, to note that the GPO are pressing ahead with an experiment aimed at the possible provision of a high speed (48 KB) switched network. It seems clear that data transmission costs will continue to fall but the rate of fall cannot yet be predicted. On the other hand new transmission facilities on any scale, including a possible digital data network (either message switched store and forward; or circuit switched), seem unlikely to be available during the first half of the next decade.

APPENDIX 3 LIST OF ASCRIBED VALUES ATTRIBUTED TO MACHINES

LESS THAN 2

ELLIOTT – 803, 803A, 803B, 903, 903B, 920, 920A, 920B, 920C, 920M
FERRANTI – Pegasus, Mercury, Appollo, Poseidon, Hermes, Sirius
Argus 350, 3512, 3516, 400
ENGLISH ELECTRIC – LEO II, III, DEUCE
IBM – 705, 1620, 1130, 1401, 1401G, 1410
ICL – 1100, 1202, 1300, 1301, 1901, 1901A, 1901S, 1902
NCR – 315, 500
DATA – 8000
ARCH – 9000
MONROBOT XI
GE BULL – GAMMA 10
HONEYWELL – DDP 124, 516
SDS 90/2
DIGITAL EQUIPMENT CORPORATION – PDP 8

VALUE=2

FERRANTI – 1600
ICL – 1302, 2400, 1902A, 1902S
IBM – 360/30
AEI – 1010
DIGITAL EQUIPMENT CORPORATION – PD 9
ENGLISH ELECTRIC – Myriad

VALUE=3

ENGLISH ELECTRIC – LEO 360
ICL – 1903, 1903S
ICL/ELLIOT – 503, 4120
DIGITAL EQUIPMENT CORPORATION – PDP 7
UNIVAC – 492

VALUE=4

COSMOS
ICL/ELLIOT – 4130
IBM – 360/40
SDS – 90/300

VALUE=6

ENGLISH ELECTRIC – LEO 326
ICL/ELLIOT – 502
ICL – 1903A, 1904, SYSTEM 4/50
UNIVAC – 1107

VALUE=8

ICL – KDF9, 1904E, 1905E
FERRANTI – Argus 500

HIGHER VALUES

10 – IBM – 360/50
    ICL – 1904F
12 – ICL – 1907E
14 – ICL – 1904A, 1907
16 – ICL – 1906
20 – ICL – 1906F, 1907F, SYSTEM 4/70, ATLAS
25 – ICL – SYSTEM 4/72
30 – IBM – 360/65
40 – ICL/1906A
    IBM – 360/75
    UNIVAC – 1108
140 – ICL – 1908A
400 – CDC – 7600

APPENDIX 4 SALARY SCALES OF THE GENERAL EXECUTIVE CLASS ON 31 DECEMBER 1969

	£s p.a.
Above Principal Executive Officer	6,000 (fixed)
Principal Executive Officer	4,620–5,200
Senior Chief Executive Officer	3,728–4,200
Chief Executive Officer	3,003–3,570
Senior Executive Officer	2,331–2,856
Higher Executive Officer	1,827–2,205
Executive Officer	683–1,691

Notes

1 All grades except that above Principal Executive Officer are paid on a specified incremental scale: only the minimum and maximum points on the scale are shown above.

2 The salaries shown are 'National' rates. Staff employed within 4 miles of Charing Cross receive a London Weighting Allowance of £125 p.a. and those between 4 and 16 miles from Charing Cross an allowance of £75 p.a.

Glossary of Technical Terms

We have used two major sources, in the order of preference given:

1. 'IFIP–ICC VOCABULARY OF INFORMATION PROCESSING', North Holland Publishing Company, Amsterdam, 1968. (IFIP)
2. Glossary (7:001.001) in the 'AUERBACH STANDARD EDP REPORTS', Auerbach Information Inc., 1967. (AUERBACH)

Wherever possible we have adopted the definition given in the first, or failing that, the second of these two reference books. Failing both, we have constructed our own definitions.

We do not attempt to include all terms which are themselves explained in the Report but in some instances we include them in the Glossary for convenience.

Terms in very common usage such as ADP, punched card, and program have been excluded but when in doubt we have included rather than excluded common terms.

Access Time	Of a computer store. The time interval between the instant the control unit calls for a transfer of data to or from the store and the instant this operation is completed. (IFIP)
Acoustic Memory	A term applied to storage devices which exploit, by their design, the properties of sound transmission through various materials.
Algol	ALGOrithmic Language: A process-orientated language developed as a result of international co-operation to develop a standard language for expressing computational algorithms. (AUERBACH)
Analogue	Pertaining to data represented in the form of continuously variable physical quantities (eg voltage or angular position). Contrast with digital. (AUERBACH)
Application	The problem or system to which a computer (or other processing equipment or technique) is applied. (AUERBACH)
Application Package	A computer routine or set of routines designed for a specific application (eg inventory control, on-line savings accounting, linear programming etc.) Note: In most cases, the routines in the application packages are necessarily written in a generalised way and will need to be modified to meet each user's own specific needs. (AUERBACH)
Architecture	A term loosely applied to the basic design of computers embracing, inter alia, the word length, instruction code, and the inter-relationship between the main parts of the computer.
Backing Store	A store of much larger capacity than the working store, but of longer access time. Data may be transferred in blocks. (IFIP)
Batch Processing	A technique in which items to be processed are collected into groups (ie 'batched') to permit convenient and efficient processing. Note: Most business applications are of the batch processing type; the records of all transactions affecting a particular master file are accumulated over a period of time (eg one day), then they are arranged in sequence and processed against the master file. (AUERBACH)
Bench-Mark	A precisely defined problem that is coded and timed for a number of computers in order to measure their performance in a meaningful and directly comparable manner. (AUERBACH)

Bureau	A general term for a computer installation available for processing data on behalf of many users. The range of services undertaken by the bureau (eg systems design, programming) will vary according to the needs of the user and from bureau to bureau. Bureaux will also vary in the degree to which they are dedicated to given tasks.
Byte	A group of adjacent bits operated upon as a unit and usually shorter than a word. Note: In a number of important current computer systems, the term 'byte' has been assigned the more specific meaning of a group of eight adjacent bits which can represent one alphanumeric character or two decimal digits. (AUERBACH)
CAD	See Computer-aided Design.
Central Processor	The central processor is that part of an automatic data processing system which is not considered as peripheral equipment. (IFIP)
Character	A member of a set of agreed elements, intended for use in conveying information either when arranged together in an agreed fashion (in general sequentially) or when isolated. Each member has one or more conventional representations on paper and in equipment. (IFIP) The most common characters are the letters of the alphabet and the ten arabic numerals.
COBOL	Common Business Orientated Language. A process-orientated language developed to facilitate the preparation and interchange of programs to perform business data processing functions. (AUERBACH)
Code	An agreed set of unambiguous rules used to specify the way in which data may be represented by the characters of a character set. (IFIP)
Compatibility	The characteristic that enables one device to accept and process data prepared by another device without prior code translation, data transcription or other modifications. Thus, one computer system is 'data compatible' with another if it can read and process the punched cards, magnetic tape, etc, produced by the other computer. (AUERBACH) See also Appendix 2.
Compiler	A program designed to transform (eg translate, assemble and structure) programs expressed in terms of one language (eg a procedure orientated language) into equivalent programs expressed in terms of a computer language or a language of similar form. A compiling program may often include an assembly

	program, a generating program and a diagnostic program. (AUERBACH)
COMPUTER-AIDED DESIGN	The use of a computer as part of a design task, eg for steel structures, electronic circuits.
COMPUTER SERIES	Especially in recent years, manufacturers have introduced ranges of computers with similar architecture. Each range is known as a series. Within each series there may be differences in processing speed, size of stores, number of peripherals, size of instruction code, etc. A considerable degree of compatibility exists between the computers within a series. See also Appendix 2.
CONFIGURATION	A specific set of equipment units which are interconnected and (in the case of a computer) programmed to operate as a system. Thus, a computer configuration consists of one or more central processors, one or more storage devices, and one or more input–output devices. (AUERBACH)
CONSOLE	In automatic data processing, an assembly of displays, manual controls etc, for use by the operator or engineer of a computer. (IFIP)
CONVERSATIONAL MODE	A mode of operation that implies a 'dialogue' between a computer and its user, in which the computer program examines the input supplied by the user and formulates questions or comments which are directed back to the user. (AUERBACH)
CORE STORAGE	A type of storage that uses an array of magnetic cores, each capable of storing one bit of data. Note: Most current computers use magnetic core storage as their main working storage. This widespread acceptance is due to the fact that magnetic cores require no power while storing data, can be switched rapidly from one state to the other by relatively small currents, and can tolerate adverse environmental conditions. (AUERBACH)
DATA	A representation of facts or ideas in a formalised manner capable of being communicated or manipulated by some process. (IFIP)
DATA BANK	A loose term for a large collection of data of similar kind, usually in coded form and usually amassed gradually. The data in a bank is normally organised to be usable for multiple purposes. Generally synonymous with Data Base.
DATA BASE	See Data Bank.
DATA CONCENTRATOR	A term used in data transmission to denote an electronic device for receiving data (usually at slow speed from several sources), organising and storing

	it, and subsequently transmitting it (usually at higher speed to a computer). The converse happens with outgoing transmission.
DATA LINK	The means by which (eg telephone line, microwave) data transmission takes place.
DATA TRANSMISSION	The transmission between remote points of data in coded form by means of signals (usually electrical). (IFIP)
DEDICATION	A loose term used to describe the extent to which a computer installation is confined to some given task or group of allied tasks.
DIGIT	A single character that represents an integer. That is in decimal notation, one of the characters 0 to 9. (IFIP)
DIRECT ACCESS	Pertaining to a storage device in which the access time is not significantly affected by the location of the data to be accessed; thus, any item of data which is stored on-line can be accessed within a relatively short time (usually less than one second). (AUERBACH)
DISC	A magnetic store in which the magnetic medium is on the surface of one or more rotating discs. (IFIP)
DRUM	A magnetic store in which the magnetic medium is on the curved surface of a rotating cylinder. (IFIP)
DUMP (TO)	To retain by storage elsewhere the contents of a set of locations either because the locations are temporarily required for another purpose or as a safeguard, eg against power failure, or for a check. (IFIP)
EMULATION	The process by which programs written for one computer may be run on a different computer. The conversion is carried out by hardware.
FILE	A collection of data, complete in some sense, for the purpose of a particular job. For example, in stock control a file could consist of the complete set of invoices for a given period. A file may be considered, where convenient, as composed of a number of records, each record containing the data relating to one particular part of a job. In the stock control example, each invoice could constitute one record. A record may be further sub-divided into fields, each field being the smallest quantity of data considered as an entity for the purpose of the job. In the stock control example each line on an invoice could constitute a field. (IFIP)

FONT	A family or assortment of graphic character representations (ie a character set) of a particular size and style; eg Font E–13B, the MICR font adopted as a standard by the American Bankers' Association, and the USA Standard Optical Font for OCR. (AUERBACH)
FORMAT	The predetermined arrangement of data (eg characters, items, and lines), usually on a form or in a file. (AUERBACH)
FORTRAN	Formula Translating System: A process-orientated language designed to facilitate the preparation of computer programs to perform mathematical computations. (AUERBACH)
HARD COPY	Pertaining to documents containing data printed by data processing equipment in a form suitable for permanent retention (eg printed reports, listings, and logs). (AUERBACH)
HARDWARE	The apparatus, as opposed to the program or method of use. Readily detachable portions of the apparatus may be termed Equipment Units. (IFIP)
HIGHER LEVEL LANGUAGE	A language used for instructing the computer which is orientated to the problem to be resolved rather than to the operation of the computer. A program written in a higher level language is translated into machine language by a compiler. Examples: Algol, Cobol, Fortran, PL1.
HOUSEKEEPING	Pertaining to operations in a program or computer system which do not contribute directly to the solution of users' problems, but which are necessary in order to maintain control of the situation: eg the recording of the locations used by different parts of a program to ensure that data is not overwritten unless it is no longer required. (AUERBACH)
HYBRID COMPUTER	A combination of an analogue and a digital computer.
INFORMATION RETRIEVAL	The methods, procedures and equipment for recovering specific information from stored data, especially from collections of documents or other graphic records. (AUERBACH)
INPUT	The process of transferring data from an external store or peripheral equipment to an internal store. (IFIP)
INTERACTIVE	Generally synonymous with 'conversational'.
INTERFACE	A shared boundary: eg the boundary between two systems, or between a computer and one of its peripheral devices. (AUERBACH)

INVERSE ADD TIME	The reciprocal of the time required to perform an addition. Usually expressed in mega-adds or kilo-adds per second.
LARGE SCALE INTEGRATION	A combination of many devices (transistor, diode and resistor) on a single integrated chip of silicon. An important development permitting much higher computing speeds. See also Appendix 5.
LASER-HOLOGRAM	A type of storage making use of the minute interference patterns of light. See also Appendix 5.
LSI	See Large Scale Integration.
MACHINE INSTRUCTION	An instruction that specifies a computer operation. (IFIP)
MACHINE LANGUAGE	A basic programming language consisting of machine instructions only.
MACHINE-READABLE FORM	Pertaining to data represented in a form that can be sensed by a data processing machine (eg by a card reader, magnetic tape unit, or optical character reader). (AUERBACH)
MAGNETIC INK CHARACTER RECOGNITION (MICR)	The automatic reading by machine of graphic characters printed with magnetic ink. (AUERBACH)
MAGNETIC TAPE	A tape with a magnetic surface on which data can be stored by selective polarization of portions of the surface. (AUERBACH)
MAGNETO-OPTIC MEMORY	A memory-utilising a laser beam to change the direction of magnetism of a ferro-magnetic film. See Appendix 5.
MEMORY	(Same as store and storage). A device intended for storage. The properties of a store depend upon the purposes for which it is intended; thus a store forming part of an automatic data processing equipment may be controlled automatically, ie without human intervention. (IFIP)
MICR	See Magnetic Ink Character Recognition.
MODULAR PROGRAMMING	Methods of sub-dividing a program into smaller parts called modules. The advantages of modular programming include easier testing and better control of programming work. The rules governing the characteristics of such modules vary from method to method.
MULTI-ACCESS	A generic term used to cover real-time, time-sharing, and remote batch-processing systems. See also Appendix 5.
MULTI-PROCESSING	The simultaneous execution of two or more sequences of instructions in a single computer system. This may be accomplished through the use of either two or

	more central processors (ie a multiprocessor system) or a single central processor with several instruction registers and several sequence counters. (AUERBACH)
Multi-Programming	A technique for handling simultaneously several programs related to various jobs by overlapping or interleaving their execution. The handling of the overlapping and interleaving execution of the various jobs is performed by a supervisory program; according to the priority requirements of the jobs it tries to optimise the performance of the system. (IFIP)
Numerical Control	The automatic control of operations (such as those of milling or boring machines) wherein the control is applied at discrete points in the operation through proper interpretation of numerical data. (AUERBACH)
OCR	See Optical Character Recognition.
One-Shot	The execution of a number of different tasks in one computer process. For example, stores issue data may be used in one-shot to adjust outstanding stock balance, debit a cost account and possibly initiate re-ordering of stock.
On-Line	If one unit can be controlled by another without direct human intervention, the first unit is said to be on-line to the second. For example remote terminals are often connected on-line to a computer.
Operating Software	A generic term to cover those general programs and routines necessary to the operation of a computer. Frequently provided by the computer manufacturer.
Optical Character Recognition (OCR)	The automatic reading by machine of graphic characters through use of light-sensitive devices. (AUERBACH)
Output	The process of transferring data from an internal store to an external store or to peripheral equipment. (IFIP) The most frequent use applies to information provided in a readable form as the end-product of the computer process.
Package	See Application Package.
Packing Density	Of a data carrier, the number of storage cells per unit area or per unit length of track. (IFIP)
Paper Tape	A tape of defined dimensions designed to be punched with a pattern of holes in defined code positions for the purpose of recording data. (IFIP)
Peripheral Equipment (or Peripherals)	All of the input-output units and auxiliary storage units of a computer system. Note: The central processor and its associated work-

	ing storage and control units are the only parts of a computer system which are not considered peripheral equipment. (AUERBACH)
PL1	A higher level language of wide scope intended to embrace both scientific and commercial applications. Largely developed by IBM, the only manufacturers who have yet issued PL1 compilers. Its future is controversial.
PROCESS	A system of operations designed to solve a problem or lead to a particular result. (AUERBACH)
(TO) READ	To obtain data from a store or data carrier. Note: In English usage, the use of the phrases 'to read to' and 'to read from' are often only distinguished from the phrases 'to write to' and 'to write from' by the viewpoint of the description. For example, the transfer of a block of data from a computer store to a peripheral store may be called 'writing to the peripheral store' or, alternatively, 'reading from the computer store', or both. (IFIP)
READ-ONLY MEMORY	A memory containing permanent or quasi-permanent information used to facilitate the operation of the computer, to perform code conversion etc. See also Appendix 5.
REAL-TIME	Pertaining to a mode of operation in which the instants of concurrence of many events in the system satisfy restrictions determined by the occurrence of events in some other, independent system. For example real-time operation is essential to computers associated with process control systems, message switching systems and reservation systems. (IFIP, AUERBACH)
REMOTE TERMINAL	An input or output device situated remotely from the computer but working to the computer by data link.
REPORT PROGRAM GENERATOR	A generator designed to construct programs to perform routine report-writing functions eg to accept input data from punched cards or magnetic tape and produce printed reports, often with headings, subtotals etc. (AUERBACH). See also Appendix 5.
RESPONSE TIME	The time-lag between the initiation of an input and delivery of the corresponding output.
SEARCH LANGUAGE	A higher level language specially designed to facilitate the retrieval of information from a computer file (data bank).
SERIES	See Computer Series.
SIMULATION	The representation of certain features of the behaviour or functioning of one system by means of actions of another, eg the representation of physical phenomena by the action of computers, or even a computer by another computer. (IFIP)

	This term is also used in a different sense as an Operational Research technique in which the operation of a real system is represented by a simplified model.
SOFTWARE	Programs and procedures associated with a data processor in order to facilitate its use. (IFIP)
SOLID-STATE	An imprecise term used to denote components that depend on electric or magnetic phenomena in solids in contrast to those depending on phenomena in a vacuum or a rarefied gas, eg transistors and other semi-conductor components and ferrite components. (IFIP)
SOURCE DOCUMENT	A document from which data is extracted, eg a document that contains typed or handwritten data to be key-punched. (AUERBACH)
STORE	Same as Memory.
STORE-AND-FORWARD	A special method of operating a network by which data is accumulated over a period of time at a message-switching centre for subsequent very high speed transmission. See also Appendix 5.
SYSTEM	A set or arrangement of entities that forms, or is considered as, an organised whole. Note: This term is a very general one that is applied to both hardware and software entities; therefore, it must be carefully qualified to be meaningful, eg (computer system, management information system, number system). (AUERBACH) We give two general meanings to the word 'system' in the report; we use it first to describe the computer system itself – ie the organisation and equipment directly associated with the inputting and outputting of data, its storage and its processing. This is a computer system. But the use of a computer for administrative applications in Government is seldom self-contained. It normally forms an integral part of an executive process, which may rest upon a complex code of practice and law, and not all of which may be directly associated with the computer. For example the PAYE work undertaken at the Inland Revenue's Schedule E Computer Centre may be described as a 'total' system. In this context the word embraces the legislative and administrative framework and the work of examining tax-payers' returns and determining their liability, as well as the process undertaken by the computer system itself in connection with the preparation and issue of documents and arithmetic calculations. We refer also to this totality as a system. The context will make clear the two distinctive usages.

TAPE CARTRIDGE	A container to hold magnetic tape. The tape forms an integral part of the cartridge which protects it and aids tape loading.
TAPE DECK	An equipment unit containing a tape transport mechanism together with reading and writing heads and associated electrical circuits used with magnetic tape. (IFIP)
TERMINAL	A point or device in a system or communications network at which data can either enter or leave. (AUERBACH)
TIME-SHARING	1 The use of a given device by a number of other devices, one at a time, in rapid succession. 2 In automatic data processing the concept is that a certain functional unit, a part of the equipment etc is controlled in different periods of time and in rapid succession by various users, programs or other units, parts of equipment etc. The sequence in which sharing takes place is controlled automatically and it can either be predetermined or can be arranged on a request basis, within a priority scheme or not. (IFIP)
TOUCH-TONE TELEPHONE	A telephone instrument so designed that it can be used for inputting small amounts of digital data accurately and rapidly into a computer system. Also known as keyphone.
TRANSLATOR	A program which translates from one language into another language. In the field of programming the term is commonly used in the more restricted sense of translation from one programming language to another. (IFIP)
UPDATING	The incorporation into a master file of the changes required to reflect recent transactions or other events. (AUERBACH)
VDU	See Visual Display (Unit).
VIDEOFILE	A document storage system allowing very large document collections to be held on special magnetic tape with the facility of rapid retrieval in the form of a visual display or hard copy.
VIEW-PHONE	A system which adds vision to normal telephone facilities. It may also be used as a visual display unit.
VISUAL DISPLAY UNIT (VDU)	An output device which presents data in a transient form (character or graphical) usually on the screen of a cathode-ray tube. It may form part of a remote data terminal system.

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Word	A group of bits or characters treated as a unit and capable of being stored in one storage cell. (AUERBACH)
(To) Write	To record data in a store or data carrier. (IFIP)

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Computers in Central Government Ten years ahead

The report, submitted in September 1969, of a team appointed to review the possible use of computers by Government Departments over the next decade.

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Foreword

This report on computers in central Government is not a statement of policy or a plan. It is a report prepared for the Civil Service Department in 1969 by a consultant team which made an independent assessment of future prospects and a number of recommendations. In view of the interest which has been expressed it is published in the hope that it will assist informed discussion and provide an indication of the scale of effort involved and the kind of problems faced. Since the report was prepared there have been many developments in this fast moving technology and changes in the organisation of work. Publication of the report implies neither endorsement of its forecasts and conclusions nor acceptance of its recommendations.

Civil Service Department
January 1971

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